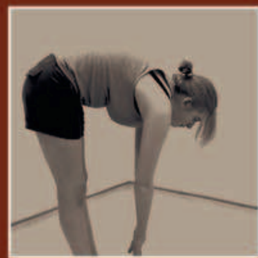
third edition

Foreword by
Mark Cooper



Dennis Purcell

Minor Injuries

A Clinical Guide

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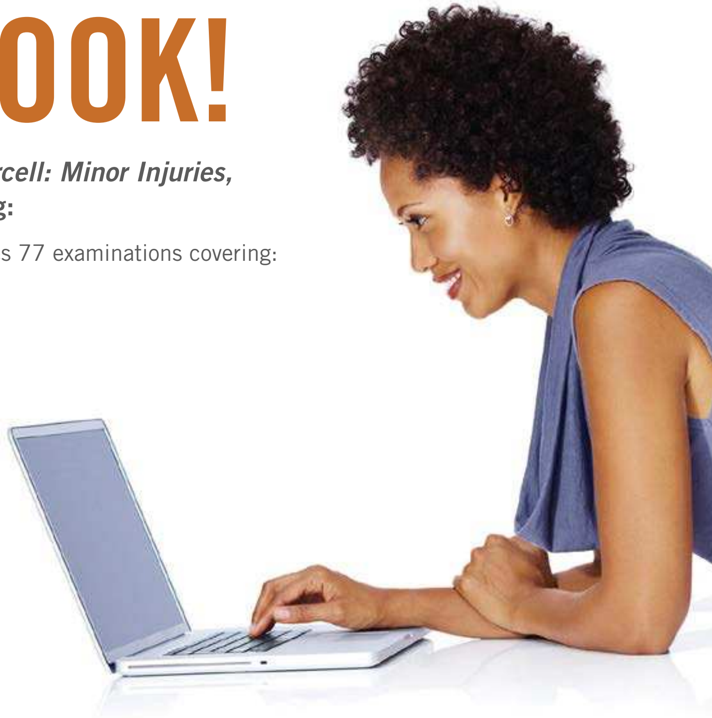

Minor Injuries

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Minor Injuries
A Clinical Guide

Third Edition

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Dedication

This book is offered with love to Lynda, Jude and Rebecca.

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Foreword

It is half a century since Nurse Practitioners were first trained in the in the United States of America, and thirty years since the role began to develop in Emergency Departments (EDs) in the United Kingdom. Since those pioneering days the Emergency Nurse Practitioner (ENP) role has come a long way. Early ENPs often had their practice restricted to a relatively limited group of injuries through the use of 'protocols' and were only found in a small number of EDs. Now, of course, ENPs are practising in virtually all Emergency Departments across the UK, and there are also numerous nurse-led Minor Injury Units (MIUs) both within the National Health Service and a growing number in private healthcare.

In the UK we are seeing ENPs practising at two broad levels. At one level we have ENPs who can see patients presenting with a well defined range of minor injuries. I remember undertaking research in my own department many years ago which showed that minor injuries distal to the knee/elbow, minor head injuries and minor wounds comprised almost a quarter of all ED attendances. These ENPs therefore can make a significant contribution to the work of a department, but will practice in departments or units where there are other clinicians who can see patients outside of this defined range.

In comparison, ENPs working in nurse-led Minor Injury Units (MIUs) need to be able to assess and, at least, initially manage whatever presents at the door. Whether it's specifically within the remit of the unit of not. These nurses need to work at a more advanced level. Ideally they should be Advanced Nurse Practitioners (ANPs).

Advanced Practice is a level of practice rather than a specific type or speciality of practice, and now, in most countries, involves educational preparation at masters degree level. ANPs can manage the complete clinical care of their patients and not just the management of a specific condition or conditions. This means that the ANP needs to always consider a wide range of differential diagnoses, especially when it comes to midline presentations. ANPs may not always be able to make a diagnosis: however they always have to make an assessment of risk and decide whether the patient needs review by another healthcare professional, and if so, by whom and how urgently. Sometimes the ANP has to make a decision to manage a patient in a way that might be outside of their usual referral pathways.

A good example of this was a patient Dennis described to me several years ago. A patient presented at minor injuries with a swollen and painful arm. The patient thought it was probably a muscular injury, but the physical examination didn't support this. Further questioning revealed that the patient had been scuba diving the previous day. An air embolism from the bends was therefore a distinct possibility. Now, the patient could have been referred to ED as this was not a minor injury. However, this would not have been the best course of action for this patient and a telephone call was made to the nearest hyperbaric chamber which was over 100 miles away. After a short debate about whether a nurse could or could not refer to the centre, a discussion of the patients presenting signs and symptoms soon confirmed that the patient needed an emergency transfer to the chamber. This example, for me, highlights the difference between a Nurse Practitioner who will work within guidelines and the Advanced Nurse Practitioner who will synthesise the clinical information in front of them and will make sound, evidence based and justifiable decision about the best care for their patient.

It is almost 20 years ago since I first met Dennis. He was working as a Nurse Practitioner in the Minor Injuries Clinic (MIC) at the Western General Hospital in Edinburgh and I was visiting as a PhD student undertaking research on the ENP role. This nurse-led unit was a pretty unique unit at that time. It was the

only nurse-led MIU in Scotland, and one of a small handful in the UK, but it was particularly unusual in that it didn't have a 'parent' Emergency Department.

The Emergency Department at the Western General closed in 1991 and in response to public pressure, the Health Board piloted a minor injuries service at Craigroyston Health Centre. Dennis ran that pilot during its year of operation and then moved to the new Minor Injuries Clinic a few weeks after its opening in November 1994.

The only essential requirements for the post were that the applicant had to be a Registered General Nurse with a minimum of four years of A&E experience. Training was provided in post and included attending an accredited one-week course at Southend Hospital, and shadowing visits to work with staff in A&E departments and a MIU at St. Charles in London.

In 1999, The Nurse Practitioners at the MIC set up their own Minor Injuries Course, accredited by what is now Queen Margaret University. I was one of the first students on that course. At that time there wasn't a minor injuries textbook aimed at nurse practitioners. There were general orthopaedic and emergency medicine textbooks and textbooks for physiotherapists, but there wasn't anything specifically on minor injuries. Instead we were given Xeroxed copies of notes Dennis had made which were beautifully illustrated with his own hand drawn diagrams (prior to his career in nursing Dennis had started a course in Fine Art at Edinburgh College before going into printmaking). It was those notes and illustrations that were later turned into the first edition of this book.

Since its publication in 2003, Dennis has continued practising as a Nurse Practitioner, moving to the Royal Infirmary of Edinburgh in 2003 then moving to Glasgow in 2008 where he has helped establish three more nurse-led MIUs.

Through his practice as a Nurse Practitioner and his teaching minor injuries to nurses, doctors, physiotherapists, and paramedics Dennis has both developed and refined how he teaches the subject. In this, the third edition of this book, he has reorganised his approach into two categories: limb injuries and injuries to the midline of the body. He has also included a chapter on X-rays and the non-medical referrer, and included numerous X-rays throughout the other chapters.

Dennis' contribution to the new speciality of Minor Injuries has been immense. Not only have the first two editions of his book become a core texts for minor injury practitioners internationally, he has taught thousands of clinicians across the UK and beyond. I don't think I exaggerate in saying that Dennis has probably taught the vast majority of ENPs in Scotland either during their initial training or at various Continuing Professional Development events. He has also played a significant part in the setting up of four nurse-led Minor Injuries Units in Scotland and co-wrote a competency framework for minor injury NPs for NHS Education for Scotland in 2004. But more important than all of that, is the exemplary care he has provided to many thousands of minor injury patients he has personally treated.

This book represents the distillation of his years of experience as an Advanced Nurse Practitioner and teacher of minor injuries. I hope this book inspires you to become a more knowledgeable and skilled minor injuries practitioner, as it continues to inspire me.

Mark Cooper

Preface

I have travelled with this book through three editions and it comes with me now to the threshold of retirement. It comes with me, aptly enough, like a nurse escorting a patient to a homebound car. I will say goodbye at the door. It will return to the fray and I will know no more about it.

The book has made a sequence of structural shifts through the three editions. It has adjusted in this way to accompany its subject, minor injuries, from its early days as a new clinical specialty and it has also accompanied the emergence of nursing as the main profession which practices that specialty.

The first edition dabbled at the edges of the politics of the profession because emergency nurse practitioners (ENPs) were still making the case for their existence. The second edition focussed more on clinical matters. The third edition has engaged with an issue which was implicit but not tackled in the earlier books, the structure of minor injuries as a specialty. Minor injury units (MIUs) offer a typical 'front door' service, characterised by variety rather than depth. This variety is a large part of the attraction for ENPs. However, it complicates our attempts to describe what we do so that the public knows and so that a curriculum for training and the title 'Emergency Nurse Practitioner' can be the same from one place to another. Improvisation has been one of the chief pleasures of the early days of our service but certain kinds of development will only come when we agree upon a few fundamentals.

My view of the structure of minor injuries has developed, not so much from clinical practice, as from teaching. Teaching, like writing, imposes the need to put things into words and to structure detailed material into larger patterns. Eventually, if things make sense in the classroom, and if they seem to carry through into clinical practice, something may emerge which is worth testing. The risk is always that an attempt to structure things, especially when the specialty includes so many odds and ends as minor injuries, is an imposition of wishful thinking on intractable material. I leave that question behind me, but I also leave something to work with.

The biggest addition to the clinical content of the new edition is X-ray. I have tended to avoid certain subjects which I consider to be better taught by specialists and X-ray has, until now, been one of these. Pharmacology is another. However, the fact that ENPs are required to tackle IR(ME)R as a condition of qualification, and that it can be difficult to obtain training which is pitched at the right level for them, has turned the scale. I have aimed to cover the material that might be required by an IR(ME)R Approval Panel to allow a new ENP to be listed as a non-medical referrer for limb X-rays.

The book addresses the emergency nurse practitioner working in a minor injuries unit. There is no intention to exclude other nurses, other sites or other professions. I am simply following the first principle of writing of every kind and staying with what I know: it seems plausible, by the same principle, that the reader is the best person to translate the material to his or her own situation.

Dennis Purcell
December 2015

Acknowledgements

In the last few years it has been my main concern, professionally, to work towards the development of a consistent way of teaching minor injuries in Scotland. I am doing that with a group of ENP colleagues, at home in Glasgow, and in Aberdeen and Edinburgh.

In Glasgow we have pooled our clinical knowledge and shared our teaching materials to such an extent that I can no longer always say where, or with whom, a given thing has originated. Happily, the group has a comfortable communality which usually makes such attributions unnecessary. We are also aware that we have invented nothing new: we reassemble existing knowledge to suit the training needs of ENPs. However, comfortable communality or not, this is a time when so much sharing should be acknowledged: Cath Evans, Ed Pool, Pauline Garvey, Mark Lilley, Linda McMillan and Laurie Pearson have all influenced the third edition. In some parts they have caused me to reshape existing material, in others they have given me something new. My gratitude to them goes a long way beyond those contributions.

I have gathered my clinical information in many different ways but none of it, as I have said above, originates with me. If I have used any person's work without an appropriate attribution that is an oversight that I will rectify when it is brought to my notice.

The book will move on beyond me if it continues into further editions, and at this point of separation I would like to look back to Edinburgh and mention again Carol Crowther, Jan Roberts, previously Jan Lumley, and Fiona Lowe, all formative influences in different ways. I must also thank everyone from the Minor Injuries Clinic at the Western General Hospital in Edinburgh, now led by Fiona Churchill and the medical and nursing team in the Emergency Department at the Edinburgh Royal Infirmary. The senior ENP there is Sue Bagley.

My children, if I may use that word in the privileged way of a parent speaking of two adults, have contributed to all editions by modelling in photographs and film. This has added much more than I will say here to my pleasure in the work. Thank you Jude and Rebecca.

Elsevier has stepped forward from the moment of my first proposal for this third edition and carried the project forward. Alison Taylor knows exactly what an author needs to hear and Veronika Watkins has combined efficiency with a light touch. Thank you.

Dennis Purcell
December 2015

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Part 1

General issues

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Chapter 1

Minor injuries: an overview

CONTENTS

WHAT DO YOU DO?

'Minor injury' is a term which lives on for want of a better. It came into use in emergency medicine as one end of a continuum which had major trauma at the other. Minor injuries were the assorted physical mishaps, domestic, social, playground, sporting and workplace, described at the backs of textbooks largely dedicated to life-threatening emergencies. Emergency department (ED) doctors were there to see every patient who felt the need to register at reception and many more who were unable to do that for themselves. At the end of a busy day an ED doctor might have seen patients with problems of every possible severity from trivial to life-threatening and his or her practice encompassed the whole scope of those presentations. There was no need to tackle the surprisingly difficult issue of defining a minor injury and it was not necessary to organise minor injuries as a separate area of study or practice.

The emergence of minor injuries as an area of practice for nurses in EDs and minor injury units (MIUs) did not change this situation. The main reason for this is that nurse-led minor injury services in the United Kingdom evolved from a series of local initiatives and they have been shaped by local needs and resources with big variations in practice from one place to another. Training has been equally variable and so have grades and salaries for practitioners.

Another aspect of minor injuries acquired new significance when the emergency nurse practitioner (ENP) began to manage injured patients and discharge them without reference to a doctor. There was a new need for a boundary not only between minor and major trauma but also between injury and illness and to ensure that ill people did not present to ENPs who were only qualified to manage trauma.

This eccentric development of minor injuries as a specialty has prevented the public from being clear about what ENPs do, which is unusual and undesirable in healthcare, especially in emergency care. There are practical reasons why a person with no time to lose should know where to turn.

In this book you will not be offered a definition of 'minor injury': that remains as difficult as ever and it does not matter. Instead you will be offered a framework that gives the specialty a logical structure and clarifies its position in relation to major injury and illness.

A FRAMEWORK FOR MINOR INJURIES

Your approach to minor injuries

There is a 'style' to the practice of minor injuries just as there is to practice in other areas of healthcare. Procedures which are nominally the same, such as the examination of the knee joint, are done in slightly different ways, or with different emphasis, in different specialties because the conditions and objectives of each specialty are different. Some defining features of an ENP in an MIU are:

- Your patients are undiagnosed and usually unknown to you. They do not usually arrive with a letter of referral. You begin with a blank page.
- You are managing patients with injuries, not illnesses.
- You work alone in a small team.
- You will only see the patient once and only for a few minutes.
- The workload in a unit may be broadly predictable but the day-to-day variations are much less so: you must work accurately and quickly.
- The range of presentations is wide and interventions are limited to immediate need.

- The fact that you are dealing only with injuries limits the possible complexity of any presentation that you will manage to the point of discharge.
- Management of a complex, chronic or serious problem will be undertaken elsewhere. Your role will be limited to the patient's immediate needs and to referral.
- Clinical history and examination are your main diagnostic tools: investigation is limited to X-rays.
- Much of your training derives from practice in the ED although you may be practicing in an MIU or other type of unit.
- In an MIU you are not seeing your patient against a background of life-and-death activity. The patient should feel comfortable claiming your attention and should recognise that you are the right person to deal with their problem.

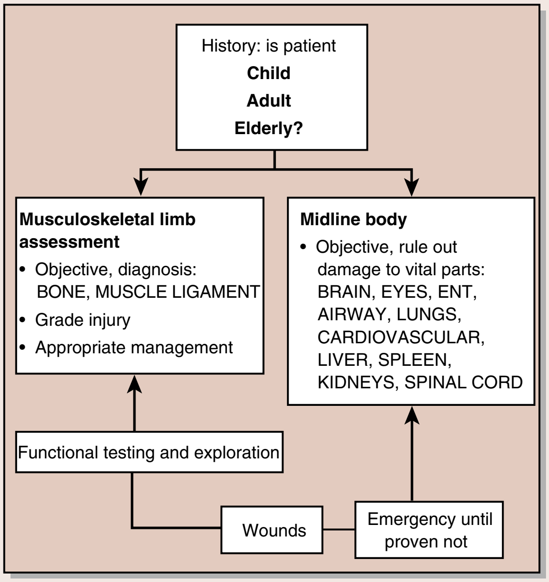
These are some of the factors which define the 'style' of minor injuries. You need a compact toolbox of techniques, guidelines and templates for the common presentations so that you have an effective response to every ordinary presentation. You are among those 'front-door' professionals who act as gatekeepers to other services. Your main efforts are directed towards the twin goals of accurate diagnosis and best initial management so that the patient will not suffer the harm that can come from misdirection at the first encounter:

- You can elicit a full history, perform a clinical examination and document a consultation.
- The aim of your examination is to make a first diagnosis of a minor injury: you do not need a wide range of special tests.
- You can grade your findings, indicating the severity of the injury, so that a management pathway accompanies the diagnosis. Any grading system is simple, ideally three or four categories which you can remember easily.
- You know the key differential diagnoses for every common presentation so that any serious possibilities are considered and excluded.
- You are skilled in the assessment of the hand.
- In addition to musculoskeletal examination, you can examine the other body systems to the extent necessary to exclude injury to major organs.
- You can assess children, adults and elderly patients with minor injuries.

Limb and midline

Patients with minor injuries present in two categories: limb injuries and injuries to the midline of the body from the head to the pelvis. Limb and midline injuries are managed differently from each other while injuries within those categories have certain things in common (Box 1.1).

Box 1.1



Patients should also be considered in at least three stages of development, children, adults and the elderly.

Injuries can be open or closed. The differences between limb and midline injuries apply equally to closed injuries and to wounds.

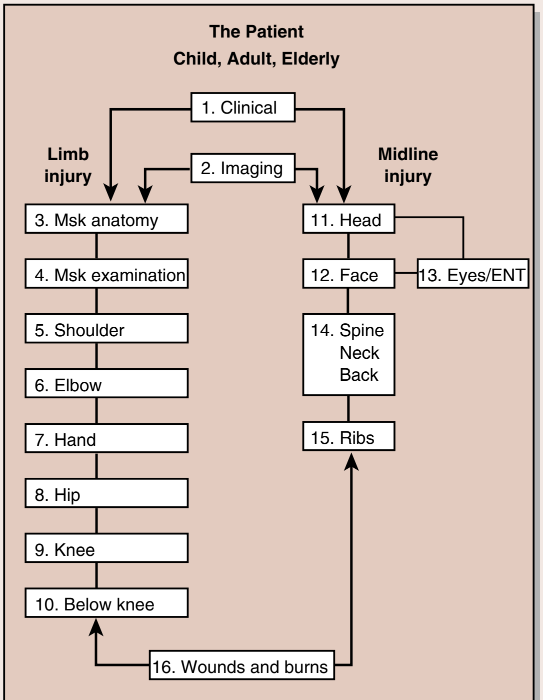
The combination of these categories, the site of the injury, limb or midline, the stage of life of the patient and whether the injury is open or closed gives us the structure with which to frame the specialty and to create training programmes for ENPs (Box 1.2).

Limb injuries are the commonest minor presentations. The main skill required to manage them is the assessment of the musculoskeletal system. Three other systems have a significant place in the consideration of minor injuries to the limb, represented by the skin, peripheral nerves and blood vessels. As an ENP you will learn how to examine, diagnose and treat musculoskeletal injuries.

The second part of this book deals with limb injuries.

Injuries to the midline of the body are approached in a different way. The aim of a limb assessment is musculoskeletal diagnosis. You are not usually asked to make a detailed diagnosis of any musculoskeletal injury that is present in the midline. Instead you are asked to assess the risk of life-threatening trauma to any major organ in the injured part of the body. The commonest midline emergency is bleeding and the effects of bleeding but other types of injury, for example to lung or nerve, are also possible depending on the injury. Your objective will not be diagnosis but a

Box 1.2



A curriculum for minor injuries

form of risk assessment which is usually structured around the question of whether the patient needs referral for some form of imaging, not only the standard X-rays of the minor injury area, but also ultrasound, computed tomography (CT) or magnetic resonance imaging (MRI) scanning. The midline organs are often inaccessible to direct examination, especially with your limited means as an ENP, and you will also interpret various indirect indicators from vital signs to national guidelines for the management of those types of injury.

The third part of this book deals with midline injuries.

Most of the book deals with closed injuries, injuries where the skin is intact. However, wounds are common minor injury presentations. In terms of limb and midline a wound is assessed by the same principles as a closed injury. You will expect to manage a large number of limb wounds definitively. Wounds to the midline raise a variety of concerns: the threat to life if a major organ has been penetrated, the threat to delicate structures such as the eyes and the cosmetic hazards of wounds to the face.

The care of wounded patients requires a range of specific skills, assessments and procedures and these are discussed in the final part of the book.

Box 1.3 The rule of threes for injuries to limb

PRESENTATION: sick, injured, overuse injury
PATIENT: child, adult, elderly
PHASE OF INJURY: inflammation, proliferation, maturation
TISSUE: bone, muscle, ligament
EXAMINE: look, feel, move
MOVEMENT: active, passive, resisted
FINDING: diagnosis, differential diagnosis, management pathway
COMPLICATING FACTORS: nerve root pain, referred pain, the capsular pattern
SEVERITY: grades 1, 2 and 3
MANAGEMENT: discharge, rehabilitation, surgical referral

Limb injuries (Box 1.3)

Some key aspects of limb injuries are discussed here. Each topic will be dealt with in full in later chapters:

- The main musculoskeletal structures that suffer injury are bones, muscles and ligaments. There are other musculoskeletal tissues in the limbs and they do get injured. The significance of these three is that they carry out indispensible functions, that they are frequently injured and that severe injuries may need surgical treatment.
- Fracture is the injury to bone that we wish to exclude. Bones localise pain well, partly because they do not refer pain as other structures do, and they are tender at the site of a fracture. Deficits in movement are not usually directly diagnostic of a fracture because similar fractures can have different effects on the movements of different patients. Palpation, touch, therefore has a key role in examination of the bones, a fact that is reflected in guidelines like the Ottawa ankle rules (see page 190). X-ray is still the commonest investigation to confirm or exclude a diagnosis of fracture and to show the features of the injury that will guide your decisions on the management of the patient.
- There is no rule-of-thumb guideline for fracture management. Orthopaedic surgeons tailor the management of each fracture to that bone and that part of the body. The severity of a fracture is judged by a variety of features including the age of the patient, the size of the bone, the site of the injury, the number of pieces of broken bone, whether the bone has broken the skin, whether the broken ends have moved apart or been crushed together, whether the broken bone is bent and how much, whether a broken part is in danger of losing its blood supply, whether a child's bone may suffer injury to its growth and how the action of the

soft tissues which are attached to the bone will influence its position and healing. Your main task is to diagnose the fracture and to make an immediate decision on whether the patient can be sent home with your treatment and an appropriate follow-up or whether he or she requires immediate referral for surgical management. Some general aspects of fracture care will be discussed in this book and you will also familiarise yourself with the ways of doing things in your own areas.

- Muscles and ligaments are usually injured by tearing. Injuries can also occur by crush and by other less common events. The percentage of the tissue that has been divided by a tear is the main factor that defines the severity and the management of an injury. You will not be able to see the size of a tear in a closed injury unless it is visibly a complete rupture. Estimation of the severity of these injuries will be discussed in Part 2.
- Injury to a muscle causes a specific movement or movements to be affected, either showing pain or reduced power and range of movement. The purpose of ligaments is to restrict unwanted movements at joints. Tears to ligaments cause pain and excessive mobility, or laxity, in those movements. Therefore the examination of different aspects of movement is the foundation of examination and diagnosis of injuries to the muscles and ligaments.
- A key skill in diagnosis of the limbs is carrying out the examination in the correct order. If bones are best assessed by palpation and the soft tissues by movement, it follows that movement tests before X-ray may not be useful, 'useful' being defined by the contribution of an examination technique to the diagnosis: and movement tests after X-ray, when you know that there is no fracture, can be used to assess the soft tissues with confidence that a bone injury is not confusing your findings. The menu of clinical tools for the diagnosis of musculoskeletal injuries is limited and you must maximise its yield.
- There are other musculoskeletal tissues that can be injured including bursa, fascia and cartilage. Meniscus, the shock-absorber of the knee, will occupy a good deal of your time as an ENP.
- The limbs contain or are closely connected to non-musculoskeletal structures that can be injured: disease which sometimes resembles and presents as injury can also show itself with symptoms in the limbs. Always assess the skin, circulation and nerves in any injured limb. Be alert for changes that suggest urgent possibilities such as infection, compartment syndrome and embolus or thrombosis. You will consider a variety of factors including the nature of the patient's pain and any non-musculoskeletal symptoms such as weight loss or fever.

You must therefore learn the anatomy and the principles of examination for the limbs so that you can decide which tissue is damaged and make a plan of management according to the severity of the injury. Your key responsibility is to diagnose fractures and to assess the severity of tears to muscles and ligaments. You must also be alert for other conditions that cause symptoms in the limbs.

Midline injuries

Minor injuries to the midline are approached differently from limb injuries. Each topic is discussed in detail in the appropriate section:

- Our concern is not mainly musculoskeletal and therefore X-rays are often of less value than for limb injuries. When we do request X-rays it can be because we wish to evaluate the effect of a fracture on another structure such as the spinal cord or to see a structure other than bone, as in the case of possible pneumothorax with rib injuries. However, the question of some other form of imaging, ultrasound, CT or MRI scanning, does arise and is frequently a key issue that we must address.
- The commonest midline emergency is from bleeding. Blood loss is often the problem. In the head bleeding threatens to compress the brain. Injuries to the vertebral column threaten the spinal cord. Injuries to the ribs can damage the lungs, heart and major blood vessels as well as liver, spleen and kidney. Injuries to the face are a threat to delicate sensory organs and to the airway. Cosmetic injury to the face is not life-threatening of itself but it is important.
- We cannot scan every patient and we often cannot directly examine the organs that might be injured. We therefore rely upon indirect indicators of the patient's well-being such as vital signs and neurological examinations and observations to help us in our decision-making.
- Limb assessment is fundamentally musculoskeletal. Assessment of the midline includes elements of most of the body's systems and you will require a broader range of examination skills to assess these patients.
- We also increasingly use national or international guidelines that correlate signs and symptoms and other features of the presentation with likely severity of injury and offer advice on when imaging is indicated. Some guidelines focus on general management of the injury rather than imaging.

- Guidelines of this kind tend to be based on the response to injury of a mature adult and they are poor predictors for children and older patients. The chief guide to a possible dangerous injury in a child if guidelines do not apply is a severe **mechanism of injury** (MOI, meaning how the injury happened). MOI is also relevant for elderly patients but other factors such as past medical history and the possibility of an injury occurring because of a collapse can also come into play.
- There is a higher risk that a patient with symptoms in the midline may have an illness rather than an injury, compared with limb presentations. The commonest sign of an injury is pain and pain also accompanies many illnesses. Evaluation of this risk will be part of your clinical process. This risk is greater at the two extremes of age.
- The risk of severe injury, the complexities of dealing with children and the elderly, regulations for arranging scans and the possible confusion of illness and injury mean that you will require senior medical advice with a larger number of patients who have injuries to the midline than the limbs: but there would be no point in accepting patients with midline injuries in MIUs if you were not able to discharge a large majority of them after a careful assessment.
- Injuries to the midline are a potential threat to the patient's life. The acceptance of such patients in MIUs is based on the confidence that serious cases are usually obvious and that those patients who self-present to MIUs are not usually seriously injured (a fact that implies that MIUs increase their risks if they decide to accept ambulance cases). A further layer of safety is added by applying widely endorsed examination and other assessment procedures and by referral when there is any risky finding. A final stage of precaution lies in the care with which discharge advice is given. The patient and the patient's relatives must know what to look for and be able to get help if the injury worsens. Head injuries cause special concern in this way because intracranial bleeding may impair the patient's alertness and may make him or her unable to summon help.

Age and stage

ENPs have often been restricted, especially in the early days of a new service, to managing patients who are adults but not yet elderly. Children and older patients are more difficult to assess and more hazardous to discharge than healthy adults. Minor injury courses have also tended to take the fit young adult as their training model.

This situation tends to evolve: patients themselves decide who is going to be seen in any given unit simply by turning up. Once a patient is in your unit you have a responsibility for his or her safety whether or not that patient is a match for your guidelines: and there is a good deal to be said for making children and the elderly welcome in MIUs rather than sending them to swell the queues in our EDs if that can be done without unacceptable risk. An MIU which is near a school or two and surrounded by GP practices will find itself being incorporated into that community's services for children. District Nurses and other health personnel will find you and they will pass the news to care homes in the area. We have an ageing population with more old people who are very active and more old people who are frail and vulnerable. They must be managed with caution when they come to hospital but many who present with minor injuries can be discharged from MIUs without referral to a doctor.

If this evolution is accepted in our MIUs it must be incorporated into our training. We must relate the stage of development of every patient to every injury and we must know the common pitfalls for injury presentations at every age and stage.

This book will discuss injuries as they affect the mature adult, but will highlight aspects that differ in children and the elderly throughout the text. Some general points are made here.

Children (Box 1.4)

Injuries to children

Specific injuries and related information on anatomy and development will be found in the appropriate chapters for those injuries.

Accidents are the leading cause of child death in the UK. Child injury occurs in certain patterns which are widely recognised and much researched. Patterns are related, among other factors, to age, gender, place, certain activities and toys, time of day, time of year and social background. Common sites for accidents are the home, the road, school, gym

Box 1.4 Stages of childhood

- Prenatal: conception–birth
- Infancy: birth–2 years
- Childhood:
  - a) Toddler 2–3 years
  - b) Early childhood 3–5 years
  - c) Later childhood 6–10 years
- Adolescence:
  - a) Prepubescence 10–12 years
  - b) Postpubescence 12–20 years (with gender variations)

and sports field. We know a lot about accidents and we regard them as exceptional, undesirable and preventable events. Healthcare professionals therefore share an obligation not only to treat injuries but also to help patients and their carers to avoid them in the future. There is an obvious role in any MIU for opportunistic education and health promotion.

The history of a child's injury is often difficult to obtain. A child's verbal maturity may be limited, or the child may not cooperate with the hospital process for a variety of reasons. Children may have been injured while up to mischief and be reluctant to divulge this: they are also afraid, reluctant to say anything that invites painful medical treatment. If the history is inadequate you will depend more on other elements of the process, witness accounts of the injury and a wider-ranging examination than might otherwise have been necessary. You may have a lower threshold for requesting X-rays, consulting senior or specialist colleagues and considering admission. You must also weigh the question of non-accidental injury.

Severity of injury will depend, as it does for adults, on the MOI. A child who is running about in his or her own living room may run into a sharp edge on a table or radiator, but the potential for severe injury is limited by the fact that no undue height or speed is involved. A smaller child who is being carried by a parent may ironically suffer a more severe injury if the parent falls. Factors such as dangerous environments and inadequate adult supervision figure in the risk.

On occasion, inappropriate sport and fitness training and other forms of physical overload can cause injuries to children, including chronic 'overuse' problems. This applies to sporting activity but also to more mundane matters such as carrying overly heavy bags of school-books. You must understand musculoskeletal development in children so that you can diagnose these problems and give advice to your patients and their carers.

The bodily differences between children and adults are numerous and significant for all fields of medical care. For patients with minor injuries two factors, both of which diminish in importance as the child attains full growth, are pre-eminent:

- The child's proportions, especially the size of the head compared to the body, dispose to patterns of injury which are different to that of the adult. Small children can be literally overbalanced by their large heads, and are more prone than adults to strike the head when they fall. Patterns of injury to the neck, which is relatively short and weak, are also influenced by this fact. Young children tend to injure the upper part of the cervical spine while older children and adults are more likely to injure the lower part.
- Children's bones differ from adult bones in a variety of ways which will be discussed in detail in the appropriate chapters: children have softer, more resilient bones, and the relative strength and resistance to injury between bone and the muscles and ligaments which are attached to them are different. The ends of long bones and the different sections of irregularly shaped structures such as the pelvis, mature from cartilage to bone during childhood, a process called ossification. It is necessary to have some understanding of this process to interpret injury presentations. Long bones generate growth from cartilage segments at one or both ends of the bones: these segments are called growth plates or physes (singular physis). Damage to the physis can cause a growth arrest in that bone and it is important to know where the growth plates are and to be able to assess common patterns of injury to these structures. When a child breaks a bone the ability of the body to correct deformity (to **remodel** the bone) is better than for adults and the healing process is much faster. Children are more prone to infections of bone and joint and to problems caused by impaired circulation to bone (**avascular necrosis**). Care must be taken with open fractures and with certain wounds such as punctures of the heel. The clinical presentation of a child with a possible fracture should define your approach. X-rays may be difficult to interpret. In addition, there may be less bruising and swelling than for an adult, although tenderness will be present at the injured site. As well as having the local clinical signs of the injury, a child with a fresh fracture often appears pale and subdued, guarding the injured part but otherwise rather listless. Most of the children's fractures which occur in ordinary falls and bumps heal without complication and they will often do well regardless of how they are treated. However, risks associated with the growth plates of children's bones, with deformities which require correction and with patterns of combined injury to different bones, mean that you should assess all children's fractures carefully. Examples of such injuries will be found in the relevant chapters. Growth plate injuries are commonly described according to the Harris–Salter classification and this is discussed in Chapter 4. Children's fractures, especially those which are near to growth plates, heal much more quickly than those of adults. This means that the time available to correct any problems is shorter.
- The same standards for wound care apply to children as to adults, although the difficulties in implementing them can be much greater. Dirty wounds must be cleaned thoroughly. A child with a wound will suffer great distress if prolonged or

painful treatment is carried out unless he or she has been properly anaesthetised. Tetanus immunity is discussed in Chapter 16. Children in the UK are usually protected but check on any who may not have been included in the system such as travelling people and those from abroad. For information on the management of wounds see Chapter 16.

Consent and confidentiality in childhood

A variety of standards are applied, not always uniformly throughout the UK, to matters as diverse as when a young person may consent to sex, marry, accept criminal liability, buy cigarettes and alcohol, vote, drive a car and give or withhold consent to medical treatment. Usually, although this is not the case with medical consent, the law settles these questions with a line in the sand. Age is the determining factor. This ignores the fact that children have a wide range of normal development patterns but it makes social policy manageable.

Young people have full human rights long before they have the maturity to use them. The boundary between the parents' caring role and the child's legitimate impulse towards independence can be difficult to define at any particular time. Consent to medical treatment and confidentiality can cause difficulty. Minor injury is not a field where problems of this kind arise very often but it does happen from time to time. The child's immaturity imposes on you a greater burden, not a lesser one, to protect his or her rights; but you must also ensure that your patient has been properly treated. While your first obligation is always to the patient, the best solution to any problem is one which is acceptable to the whole family.

The UN Convention on the Rights of the Child (1989; ratified in the UK in 1991) states that a child who understands the issues has the right to consent to his or her treatment. In England, Wales and Scotland, a child who is under 16 years of age may consent to medical treatment if a doctor is satisfied that he or she understands that decision in the sense of the term 'informed consent' (Box 1.5). A child who has this understanding is sometimes said to be 'Gillick competent' (Box 1.6). English law, not operative in Scotland, allows a competent child to consent to treatment but may not allow the child to refuse it: the courts or, on occasion, the parents can overrule refusal. In Scotland, the court can do this but the parents cannot: the child in Scotland has more power to refuse treatment if the conditions for an informed consent are met.

Morton and Phillips (1996) offer an interpretation of consent from the viewpoint of senior doctors working in an ED in England:

- When a parent or a carer brings a child to an ED for treatment, the consent of the adult to the child's treatment is implicit if the treatment has been explained.

Box 1.5 Competence to consent

A competent child must:

- understand the concept the doctor or nurse is explaining and have the memory to retain that information
- believe that information to be true
- be able to balance the consequences of treatment versus non-treatment.

Box 1.6 Gillick ruling

Gillick v West Norfolk & Wisbech AHA 1984–1985: a minor can consent if he or she has the understanding to decide. This overrides parental rights, but we should always try to obtain parental consent: 'As a matter of law, the parental right to determine whether or not their minor child below the age of 16 will have medical treatment terminates if and when the child achieves a sufficient understanding and intelligence to enable him to understand properly what is proposed'.

Gillick was confirmed in the Children Act 1989 and the Children (Scotland) Act 1995, which allowed mature minors younger than 16 years old to consent to treatment.

- If the child needs an anaesthetic, written consent should be obtained. (In general, written consent should be sought for procedures which carry significant risk, or which are invasive or intimate.)
- If a child of 12 years or older comes to an ED alone for treatment, every effort should be made to contact a responsible adult to obtain consent. If no adult is available and the child is competent, then minor treatment, not including X-rays or the giving of medicines, might be performed.
- At the other extreme, in a dire emergency, life-saving measures can be undertaken without consent if the child is alone. The situation should be documented and continuing efforts made to locate the parents. The parents should be informed in writing of the action taken.

Medical treatment is sometimes imposed on young children against their stated desire if treatment is in the child's long-term interest and the refusal is deemed to be, perhaps, the result of stress. Consent is obtained from the parents. You should remain aware of the child's rights, give an appropriate level of explanation, and minimise the potential for the treatment to add to the trauma of the original injury. A children's ED has options such as sedation and theatre treatment for dealing with these problems. Refer at the outset if there is any doubt.

Box 1.7 Five questions for assessment of risk of non-accidental injury

- Injury inconsistent with mechanism?
- Injury inconsistent with development?
- Do you have concerns with child or family?
- Was there an UNEXPLAINED delay?
- Is the history variable between accounts?

If a child is competent to consent he or she has the right to patient confidentiality and this includes the right to withhold information from his or her parents and carers if the child insists upon that. This right can be overruled in certain situations: notifiable disease, child protection issues, road traffic accident, terrorist event, a threat to the safety of others or a court order. These stipulations also apply to adults.

Non-accidental injury (Box 1.7)

Another issue which arises from the relationship of children with their carers is the vulnerability of children to abuse from those who are supposed to be nurturing them. Children may also suffer from sustained bullying outside the home, usually at school. We all share the responsibility to act on the suspicion that a child is being abused, but as an ENP treating injured children you are certain at some time to meet a child who has been deliberately injured or abused in some other way and you must be:

- trained to recognise the situation in its common manifestations
- aware of the processes by which the issue is managed in your area and of the legislation which supports such activity in your country
- skilled at taking your place in the larger child protection team: you are likely to be the person who raises the first concern and this must be done with tact and the avoidance of any premature accusations.

Non-accidental injury (NAI) is the term used to describe physical trauma deliberately inflicted on a child, a form of abuse which one might expect to confront in an MIU. There are other forms of abuse, sexual abuse, emotional abuse and deprivation, and neglect, and you must be alert for the signs of any of these.

In the United Kingdom since 1999, when health and social care was devolved to the national assemblies of England, Wales, Scotland and Northern Ireland, each country passes its own laws and has its own child protection system. As an ENP you will be trained in the skills that you require for this role and in the processes by which you perform it.

Box 1.8 Analgesia for children

- For mild to moderate pain, use paracetamol.
- For more severe pain than above, use codeine phosphate and diclofenac.
- For severe pain – morphine: nasal administration avoids needles, calms the child, acts quickly, lasts for 30 minutes. Go to intravenous administration when cannula is sited. (Have naloxone available for reversal.) Antiemetics are not usually needed.
- Follow the instructions in the British National Formulary for Children for dosage.

Analgesia (Box 1.8)

It is easy to give a child an overdose of medicine. Calculation of dose may be based on age, on weight, or on an estimate of total body surface area (BSA) of the child. Any of these approaches may be inadequate in the presence of a patient who is not in the normal range: an obese child, in terms of capacity to metabolise medicines, may be lighter or smaller than a weight or BSA reading would suggest and will be more accurately dosed by a calculation based on age. The reverse may be true of a child whose growth is uncommonly in advance of, or behind, the average, when weight or BSA will give a better approximation than age for dosage. Follow the recommendations of the British National Formulary for Children for each medicine and for calculation of BSA. Children's paracetamol and ibuprofen are prescribed by age: advise carers to follow the instructions on the bottle for home dispensing.

Do not overlook the need for analgesia. Distress may look like fright, and silence like calm. Pain may be influencing either appearance. Children may not say how painful the problem is because they fear treatment. A pain score is helpful and there are visual tools using drawings of happy, neutral and sad faces for young children (Fig. 1.1). Measures such as the use of a sling or a splint to immobilise a fracture, ice for a swelling or water cooling for a burn can have analgesic benefit. Distraction with play, toys, pictures and films can be very effective. The reassurance of a parent's presence can reduce distress and bring pain into a different perspective.

Oral paracetamol in a child's liquid suspension, is very effective for the pain of minor wounds, burns and musculoskeletal injuries.

Children and sports injuries

Sports injuries are not dealt with as a separate subject in this book: they are a subject and, indeed, a medical specialty, in their own right. Specific injuries are discussed in broader terms, mechanism, severity, management and outcome. The issue of whether they occur during sport or as a result of some other activity is secondary. However, you will occasionally analyse a

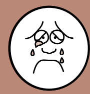
	No pain	Mild pain	Moderate pain	Severe pain
Faces scale score (circle)				
Number score (circle)	0	1–4	5–7	8–10
Behaviour (circle each relevant observation)	Normal activity No ↓ movement Happy	Rubbing affected area Decreased movement Neutral expression Able to play/talk normally	Protective of affected area ↓ movement/quiet Complaining of pain Consolable crying Grimaces when affected part moved/touched	No movement or defensive of affected part Looking frightened Very quiet Restless, unsettled Complaining of lots of pain Inconsolable crying
Injury example	Bump on head	Abrasion Small laceration Sprain ankle/knee # fingers/clavicle Sore throat	Small burn/scald Fingertip injury # forearm/elbow/ankle	Large burn # long bone/dislocation Appendicitis Sickle crisis
Category chosen (tick)				

Fig 1.1 A pain score for children.

patient's history of a sports injury for avoidable risks and you will give advice on the prevention of further accidents. This obligation is at its greatest when the patient is a child, partly because a child is a dependant in the ordinary way of children and partly because the potential for harm to a developing body from inappropriate training and play can be greater than parents and teachers may realise. It is therefore useful to acquire some basic concepts from sports medicine to help you to look beyond the individual injury to problems which might lead to a recurrence of the injury or injury to other people.

Children play organised sport and are involved in related activities such as exercise sessions in the school gym from at least the start of school and many continue this activity until they leave school and beyond. Some will show signs of a special talent and may be training to a high level from an early age. In addition to school sport the child may be involved in casual play, extramural sport training and other demanding physical activities such as dance.

Healthcare professionals and others who are involved in the organisation of children's sports have a responsibility to ensure that children do not suffer any injury as a result of inappropriate forms of activity for their stage of development, or as a result of poor preparation for these activities. Sports injuries can be usefully considered under two headings, the child's own physical development and attributes, and the nature of the sport itself, the equipment, training, conditions, rules and patterns of injury which are typical for that sport.

The Child

Adolescent boys have a higher natural aerobic capacity than girls and continue to develop that capacity until they are older. Boys are stronger than girls. In adolescence, boys increase in strength until at least 18 years while girls level off at around 15 years. The pace of increase is not consistent, with surges of increase particularly marked in pubescent boys. Muscular endurance, the ability to sustain activity over a long period, is more equal between the genders and increases at puberty, but boys continue to gain in adolescence for longer than girls. Boys are less flexible in their joints. Boys who enter adolescence early have a performance advantage over later developers. This factor, the child's biological age rather than his chronological one, should influence his placement in team games. Girls, on the other hand, may benefit, at least in some activities, from late development by having better control of weight and a more linear physical progress. Active children have proportionately less body fat than inactive ones. There is dispute about the exact link between body weight and exercise in young children but, given that obesity is linked to poor

health and exercise to good health, there are clear reasons for the promotion of sport among children.

Two questions asked by researchers are, how do prepubescent children respond to training and do they benefit from routines designed to improve the various categories of physical performance? Adolescents benefit from training but the situation is less clear in preadolescents. Young children are partly limited in their attainments because they are still acquiring physical coordination and balance. They are also difficult to assess under research conditions. It appears to be difficult to enhance their aerobic capacity by training. There is some evidence that strength can be improved, with benefits in sports performance and reduction of injuries. However, it is not appropriate for young children to train with heavy weights or to full power. Injury may happen to the growth plates of bones both by overload and overuse and any expected benefits from training must be weighed against that risk. It may be more valuable to focus on skills training in children than strength.

At key stages both before and during adolescence children will have growth spurts, a situation where the bones lead and the muscles follow. If the bones have recently grown the muscles will tend to be slightly short for the longer frame. This will appear as a loss of joint flexibility, and careful warm-up and reduction in activity at times of growth are advisable. This situation also leads to avulsion fractures (the tight muscle pulls off its bony insertion point) which are overlooked because they are mistaken for muscle tears. An adolescent who engages in an explosive sport like sprinting, and who has had a recent growth spurt, presents with a history of sudden leg pain, perhaps high on the hamstrings, while running. You may find that he is tender on the ischial tuberosity, the pelvic insertion of three of the four hamstrings, and X-ray confirms that the injury is a fracture. The combination of tight muscle and soft, immature bone causes the injury.

Preparation for sport, especially at a high level, should include the detection and correction of musculoskeletal problems such as muscle tightness and weakness, tightness or excessive mobility around joints and poor alignment of the body. The involvement of a physiotherapist is invaluable. There should also be appropriate training for both general fitness with harmonious physical development, and the skills and physical attributes which are necessary to perform the sport well without injury. Such training should be planned through the season and must include adequate rest time. In sports where there is heavy contact, such as rugby, the child's size and biological stage of development are more important for his or her selection for a team than chronological age.

Muscle tightness is implicated in strains and tendon inflammation, and may also have adverse effects on joints by restricting their mobility. Muscle weakness is a factor in overuse problems. The balance in length and strength between opposing muscles is also important, and training should be directed to harmonious development. If a muscle is overdeveloped in relation to its neighbours the imbalance can cause changes in joint and muscle function, and can give rise to acute injuries and chronic pain.

Joints which are excessively mobile may lack stability. There may also be excessive wear caused by contact between surfaces which would not meet in the normal joint. Ligament injuries heal slowly, and there is usually a loss of coordination and stability in the joint caused by damage to the nerves of proprioception (see Chapter 4). This may lead to fresh injury. Children with significant ligament injuries should have a rehabilitation programme which includes proprioceptive training, a process which a physiotherapist would normally supervise. Children with loss of proprioception will have particular difficulty with complex joint movements, jumping and dancing on uneven ground or during the twists and turns of field sports.

Problems with alignment of the different parts of the body are most marked in the leg because of the stresses of weight bearing, with a list of conditions which includes Achilles tendon pain, shin splints, stress fractures of the leg and foot, patellofemoral pain, patellar dislocation and iliotibial band tightness. Flatness of the medial arch of the foot, an excessive angle of the femur from hip to knee (the 'Q angle'), and differences in leg length are among the conditions which are implicated.

Correct warm-up and, to a lesser extent, cool-down routines help to prepare the body for effort and reduce injury, especially early in a game. These can include light aerobic activity, stretching, resistance exercise and drills for the sport. Stretching is best done after the aerobic session has increased blood flow to the muscles.

The Sport

Each sport has its own patterns of injury. Injuries in certain sports are of a violent type and in some there is a balance between open and closed injuries. In other sports the tendency is almost entirely to overuse problems and these will reflect the patterns of recurring movement that the sport requires. Overuse pain in children requires careful assessment to rule out disease, damage to growth plates and other changes in bone.

Overuse is common in running, gymnastics, dance and in swimming. In running, the leg will be affected. Overuse in swimming relates to the stroke which is used, with a distribution over the whole body.

Contact sports tend to cause violent injuries with fractures and wounds. The use of the head and neck in rugby and the role of the arms in tackling, mean that there are more upper body injuries than football and an incidence of serious spinal injury. In football there is some elbow-to-head and head-to-head contact, but many of the injuries are from leg-to-leg tackles and from twisting injuries to ankles

and knees. Position in the team can make a difference to injury pattern. Goalkeepers are more at risk of serious head injuries than other football players.

In sports like cricket and baseball, throwing the ball is a crucial part of the game, with repeated delivery from a raised arm. Overuse can affect the growth plates of shoulder and elbow, and the muscle and joint structures of the shoulder can become painful. The twisting motion of the trunk when a cricket ball is being bowled can also cause pain in the lower back.

Small, hard balls used in sports like squash cause injuries to the globe of the eye itself, whereas larger balls will injure the surrounding bone. Weapons such as swords, guns and bows can cause penetrating injuries. Any game which involves stick, bat, racquet or club will have an incidence of accidental impacts from these objects. Golf seems to be the least aggressive of sports but standing behind a player when the club is swung can result in an open, depressed fracture of the skull.

Sports which involve height or speed, skiing, high-diving, horse riding and mountain biking, have an incidence of more dangerous injuries because these factors increase the severity of the MOI.

Children must be trained in the correct techniques for a sport in order to reduce injury. In sports where jumping or falling are involved, such as netball and judo, safe ways of landing must be learned. This does not entirely remove the problem where the action is dangerous even when it is performed correctly. In that case the sport may need to alter elements of the play for children. Changes in techniques and tools are an ongoing part of sport. Tennis causes a large number of overuse injuries, many of them to the arm, and the techniques of serving and returning the ball are constantly evolving, and racquets, shoes and other equipment of the game are in continuous development. Soccer has outlawed certain patterns of tackle from behind or with the boot raised to reduce the danger of injury. Sports like rugby, where the adult game is too dangerous for young children, can change rules and equipment to reduce the risk. The quality of supervision and refereeing is important for children, and this needs to be done by people who are aware not just of the sport but also of the needs of young players.

A further method of reducing danger can be the use of protective clothing. This should be well designed, fitted and maintained and its use should be carefully thought through. Sometimes protection can increase rashness. Helmets which removed inhibitions about the use of the head as a battering ram in American football were discovered to increase the number of injuries to the neck. Protection can be given in five ways: dispersal of impact (shin guards), absorption of impact (padded shoes), deflection of blows (helmets), protection from penetration (fencing masks) and restriction of excessive movement (strappings and splints). Devices which limit vision, breathing, hearing or movement are dangerous. Devices which are designed to protect a joint from injury by immobilising it can reduce injury, but they may also prevent a normal protective reflex or deflect the injury to another part of the body. Mouth guards and shin pads are usually helpful in contact sports. Eye protection is vital in fencing. The number of torn ear injuries in rugby has been reduced by using head bands. Bicycle helmets reduce the number of less serious head injuries but not the death rate for cycling accidents, because cyclists are usually killed by cars.

Footwear is a major factor in all land sports. One of the technical challenges is to provide enough friction between the shoe and the playing surface so that players will not slip, but not to have so much that the foot becomes fixed and the ankle or knee injured. Padded shoes which are designed to absorb impact need to be well fitted to support the target area and changed when the padding is no longer effective.

Preparation for play must always take weather and temperature into account. Clothing which will keep players adequately warm, but not overheated, is required. Hydration must always be maintained at a healthy level both for temperature and levels of activity. High levels of glycogen are required for good sporting performance and a child should have eaten in the 3 hours before the activity and should top up on fluids and salted food during it.

In some sports the training phase is relatively safe and injuries tend to occur when the game is played. In others this distinction is much less clear. Most football injuries occur during play. Runners are as likely to suffer injury while training. Play at a high level tends to produce more injury. In team sports the incidence of injury related to deliberate foul play increases. Some sports demand complex and dangerous play to make the performance more exciting. This is seen in ice skating, diving and gymnastics.

Adolescents tend to be injured more than younger children. Patterns of injury move towards the adult pattern as the child reaches full growth and adult proportion. Age-related patterns of injury are discussed at the appropriate places in the text. Boys are injured more than girls but this difference is reduced or disappears if they are playing the same sport. Body types, the lean ectomorph, the round endomorph and the muscular, compact mesomorph, have no established relationship to a tendency to be injured, but there is clearly a need to match the physical attributes of a child to the demands of the sport, or the role in a team, for which he or she is selected.

The elderly

One issue above all others complicates consultations with older patients in MIUs; the question of a medical cause for a fall. Elderly patients may collapse and suffer injuries to the face and limbs (be cautious if the patient

injures the face with no sign of putting the hands out as he or she fell, a pattern which is seen with collapse) and they may then present to MIUs that are not equipped to investigate the medical situation. The patient may have dementia, or may fear hospital admission and be inclined to downplay the incident or deny the collapse outright. Once again, as with children, witness accounts of injury, and the impressions of someone who knows the patient, can be helpful.

The proximity of all consultations with older patients to medical concerns means that you will always obtain a detailed medical and social history and your threshold for recording vital signs and undertaking basic tests, such as urinalysis and BM measurements, will be much lower than for a younger patient with a similar presentation.

The discharge of an elderly patient will always involve an assessment of the patient's social circumstances and that will be part of the history. Many of our old people live alone; many have stairs and will not be able to reach bed or bathroom with an ankle injury; many have declining cognitive abilities. Family, primary care and social service connections are important. These factors must be explored for a minor injury just as they would be if the patient had been admitted to hospital with an illness.

The process of caring for an old person can be difficult to assimilate into an MIU. Units usually have low staff numbers and a fast turnover of patients. An elderly person will do everything slowly. You will often have to ask the patient to undress for a head-to-foot examination. Be careful to adapt to the demands of this change of pace: if you rush you will miss something.

Older patients may have changes to their movements and faculties that are the result of degeneration, old injuries, previous surgery and illness. It can be difficult to know what is normal for them during examination and on X-ray.

Our bones weaken as we age and the threshold for X-rays is lower for elderly patients. The patterns of injury change and the patient's response to injury may also change. It is common, for example, for elderly patients with ugly wrist fractures to be relatively untroubled by pain and not to be very tender. It is instructive to see, on the rare occasion when it happens, a young adult with a similar injury: the pain is severe. This means that you must be alert for clues to possible injuries such as reluctance to walk or to use a hand when more obvious signs of injury are absent.

A feature of injuries to older patients is an unnoticed second injury. If an old person trips and injures a wrist, and is brought by ambulance to hospital, it can happen that they have not stood up since the fall and do not realise that they have a painful hip. If they have dementia, the history will be poor and the examination must supplement the lack by extending beyond the presenting complaint, frequently to the extent of undressing the patient and doing a head-to-foot survey.

The elderly have an increased sensitivity to the effects of medicines and they are at risk from the complications of polypharmacy: do not administer or discharge them with powerful analgesics without consultation and precaution. Take a careful history of the patient's use of medicines.

Apart from the usual pathways for referring patients for admission you will, from time to time, refer elderly patients for assessments of their mobility and their home facilities so that they can be discharged in safety.

Non-accidental injury is a phenomenon which can be found among any group of patients who are dependent on carers and this applies to the old as well as the young.

Chapter 2

Clinical examination and the written record

CONTENTS

MINOR INJURIES AND THE CLINICAL PROCESS

This book offers an approach to the management of patients with minor injuries. Chapter 1 described this approach in general terms. In this chapter you will apply that approach to the **history**, the story of the injury, told to you by the patient at the start of the consultation. The patient tells you who they are and what has happened to them: afterwards you will carry out a physical **examination** based on that account. These activities, 'taking a history' and examining the patient, are the **clinical process**.

This chapter will explore the first part of the clinical process, the history, and it will also discuss the documentation of the whole process. The second part of the process, the physical examination, will be discussed in its relevant varieties in the following chapters.

The clinical process has core elements which are the same for every specialty, but it also varies in its details from one area to another. You will see how to adapt it for our model of minor injuries. Minor injuries are divided into two branches, limb injuries and injuries to the midline of the body, and they each require a slightly different approach. You also modify your approach to the patient depending on his or her stage of life: childhood, adulthood or old age. These elements shape every stage of the consultation and your written record of that event.

The clinical record is first of all a written note of your encounter with a patient but it is more than that: it is the template for the physical process of talking to and examining the patient. The written record and the actual examination are not the same thing any more than a riverbed is the same thing as a river, but they can reflect each other in a similar way. Each consultation can be structured around the framework of the record, and each record can describe every important thing that was said and done, or not done, during the consultation. The written record is not just a note of what has happened, it is a reflection of the method and the sequence that you follow with the patient and the diagnosis should flow logically from it.

WHAT DOES CLINICAL MEAN?

'Clinical' is a word that, in healthcare at any rate, is heard everywhere: and yet, there is often a pause if the speaker is asked what it means. What does it mean?

The word is encrusted with medical associations, tiled rooms, examination trolleys, white coats, disinfectant, metal instruments in kidney trays. These associations evoke the fears they seem to be designed to suppress, of pain, loss of control, decay and death. In the spirit of those impressions, 'clinical examination' is a term which has come to have rather impersonal associations, of a technical process carried out by an expert 'clinician' on a passive agent, the 'patient'. Indeed there is an alternative terminology for the history taking and examination phases: they are called the 'subjective examination' and the 'objective examination'. This terminology implies the unreliability of the patient's perspective and the clinician's detachment.

The root of the word 'clinical' is more homely. 'Klinikos' is the Greek word for 'bed', and clinical activities are those which happen at the bedside between you and your patient as you try to find out what is wrong with him or her. The clinical process consists of a conversation between you and the patient and an examination by you of the patient's body based on that conversation.

The conversation, or the history, is at the same time a social interaction using all of the skills which ordinary conversation requires and a professional encounter with a clear objective. For a good outcome it depends upon communication skills, empathy, keen observation and the ability to listen. Physical examination is more obviously a technical process than taking a history but it cannot be done without the trust and cooperation of the patient and that is something that you must win during your conversation.

The objective of the clinical process is to discover what is wrong with the patient, to reach a **diagnosis**. Diagnosis is another word that is derived from Greek: it means 'knowing one thing from another'. The information from the clinical examination may lead to further actions before or after diagnosis. These may include investigations to clarify the diagnosis, and treatment or referral to another clinician.

When patients with minor injuries require investigation, X-ray is almost always what is wanted. The menu of further investigations is limited. Clinical examination is therefore the chief tool and the chief skill which you must develop for the diagnosis of minor injuries.

Diagnosis, differential diagnosis and the management pathway (Box 2.1)

Your patients are usually undiagnosed when you meet them. Your key responsibility is to find out what is wrong with them. If you bring a patient needlessly into the healthcare system or if you discharge someone who should have been directed to a specialist then your misjudgement may be troublesome or even dangerous for that person. As a gatekeeper at the front door of the health service the decision that you make about the patient's next step is the most important part of your role. Until you reach a diagnosis, everything you do is flowing towards that point: once you have your diagnosis, everything flows from it.

Box 2.1 The rule of threes for injuries to limb

PRESENTATION: sick, injured, overuse injury
PATIENT: child, adult, elderly
PHASE OF INJURY: inflammation, proliferation, maturation
TISSUE: bone, muscle, ligament
EXAMINE: look, feel, move
MOVEMENT: active, passive, resisted
FINDING: diagnosis, differential diagnosis, management pathway
COMPLICATING FACTORS: nerve root pain, referred pain, the capsular pattern
SEVERITY: grades 1, 2 and 3
MANAGEMENT: discharge, rehabilitation, surgical referral

However, it is hardly likely that an emergency nurse practitioner with limited resources to investigate, meeting large numbers of new, undiagnosed patients every day, each for a few minutes only, will be able to find out exactly what is wrong with every person. Medical specialists who have much greater scope to assess their patients may be obliged to search for a diagnosis over many consultations. There are, as there must be, ways to manage patients when a diagnosis is not yet available. In fact, given that many minor injuries resolve quickly and that most patients are only seen once, many are managed from start to finish without a diagnosis.

Certain presentations are always difficult to diagnose: a common one in minor injuries is joint pain with no history of injury. The appropriate approach to this situation is to establish a **differential diagnosis** and use that as the basis for a management plan. You do not know what is wrong with the patient but you are able to make a list of the likely causes for this presentation. The list for joint pain includes arthritis of different kinds, gout and overuse injury. In order to arrive at a management plan for the patient you must exclude from your list any problem which is so dangerous that it must be diagnosed and treated immediately. The main concern of this kind in cases of joint pain is infection within the joint, septic arthritis. If you are satisfied that your patient with a painful joint does not have an infection you can formulate a plan to manage the symptoms and follow the patient up if that is necessary. If you send a patient home without a clear diagnosis be careful to provide a **safety net**. In the case of joint pain you do this by advising the patient on symptoms which would suggest that an infection was developing, such as fever, malaise and worsening symptoms at the joint itself. Tell the patient what he or she should do if there are reasons to be concerned and then document the advice which you have given in your clinical notes.

On rare occasions, often with new problems where the symptoms have begun quietly, it can be difficult to reach a diagnosis, and even difficult to formulate a differential diagnosis. In that case you have to decide whether the patient should be treated as an emergency or referred less urgently, usually to his or her general practitioner (GP). You require a **management pathway** for an undiagnosed patient. The principle for resolving this issue is to assess the patient's general well-being and then to focus in on the lesion which is being complained of. Take a detailed medical history; discover whether there are any systemic problems coinciding with the new complaint, whether the patient is on a lot of medicines or any new medicines. You may wish to record vital signs, and you may undertake simple investigations such as urinalysis and BM. After that, look at the lesion and ask how it has developed and how it is behaving. A presentation of this kind may merit a discussion with senior medical colleagues. If the patient's problem raises serious concerns make an urgent referral to

a relevant specialist. If there is no evidence of an emergency problem, based on an assessment of the patient's general health and of the specific complaint, make a plan for the patient to be seen by his or her GP. Again, document your actions and ensure that the patient knows what to do when he or she leaves you.

THE CLINICAL RECORD

The written record of the clinical examination has two important functions:

- It is essential for continuity of treatment for your patient. The GP has ultimate responsibility for the integration of the patient's medical care and should receive a report on any treatment which he or she has received.
- It provides evidence of what happened during the examination. Injured patients occasionally come to the civil or criminal courts. They may come to court to sue you, or your employers, if they feel that you have been negligent in your care. The court will most easily be able to accept your account of events (especially in the situation where someone else's account disagrees with yours) if a written record made at the time of the episode supports your later statements. 'If it isn't written it didn't happen' is an oversimplification, but a well-written note is a powerful ally.

The written record has other uses. It carries data which can be used for audit. Electronic patient records allow increasingly sophisticated ways of retrieving and auditing information. The use of confidential patient information must accord with the rules governing both the ethics of research and data protection laws. You can obtain information locally about the management of such issues in your area.

The value of the template of the written record to organise the physical process of examination has already been discussed.

The double status of the written record, as a medical and as a legal document, means that it must conform to certain standards:

- Identify the patient by full name, date of birth, address and Community Health Index (CHI) number if that is available. If continuation sheets are used, record the patient's name and date of birth on each sheet.
- Note the date and time of attendance, as well as the time of triage, if that occurs, and the time of starting and ending the consultation: if the patient is seen more than once, record the date and times of each visit.
- Sign the notes and write your name and designation in capitals below the signature. Anyone who writes on the sheet should sign it. This may be, for example, another practitioner, a nurse who has checked a prescription or a radiologist who has recorded an X-ray report.
- If the treatment sheet is handwritten, it must be legible. Write in black ink and use abbreviations only if they are widely understood and unambiguous.

Technical language

Write a clinical note as simply as possible. However, ordinary language does not always give you words which are clear enough and you may need to use some kind of technical language.

'Technical language' means words which are either not in common use or are common but are used in a special way. Advice to patients on the care of injuries is a vital part of your work but you must deliver it in a way that is understood. Much of the medical language which causes misunderstanding in minor injuries (words like 'trauma', 'fracture', 'sprain' and 'strain') does so because people know these words and do not realise that we are giving them meanings which differ from ordinary usage.

Technical language in minor injuries usually belongs to one of five categories:

- anatomical terms for parts of the body
- terms which describe the movements of parts of the body
- terms which describe the position of one part of the body in relation to another
- ways of describing where on the body a lesion is to be found
- types of injury.

Anatomical names are not always necessary. The everyday equivalents are often just as precise as the Latin ('knee-cap' for 'patella', 'collar-bone' for 'clavicle', 'shoulder-blade' for 'scapula' and so on). Many Latin names are widely known, especially among sportsmen. However, other everyday words such as 'stomach' are often used vaguely and it may not be clear whether the patient has chest pain or a problem in the abdomen. 'Shoulder', as the word is commonly understood, describes a group of joints and a more exact description is sometimes needed.

Everyday language is not good at describing positions and movements of the body. To say that an injury lies below the wrist, when the hand can be held above or below that joint, is unclear. The outside of the hand can be any surface depending on how the arm is rotated. To say that the patient's finger, wrist or ankle hurts because he 'twisted it' does not give a picture of the exact movement. That picture is needed to narrow down the range of injuries which might have occurred.

Pay attention to simple matters. Record whether the right or left side is affected, whether an injured digit belongs to

the hand or the foot, and which joint of a finger is painful. The standard to aspire to is that a person who reads the account later, when the patient is not present, can reconstruct every important fact.

Diagrams

A treatment sheet will probably contain a space for a diagram, and certain injuries, especially wounds, lend themselves to pictorial representation.

It is not necessary to be an artist to do this. It is fine to draw a bunch of bananas but you must label the picture so that the reader knows whether these are hand bananas or foot bananas. Label it even if it appears to be totally clear to you, saying left or right, front or back, naming the body part and sketching the injury. Some treatment sheets provide diagrams of the body and there are also rubber stamps available which depict all parts of the body.

Common terminology will be defined throughout the book.

THE CLINICAL HISTORY

The taking of a history is a social act, a conversation, and it calls for the skills which mark the conversationalist, warmth, empathy, listening and a grasp of the nuances of unspoken communication. However, it is not a casual conversation. It occurs in a very unequal situation. You are in control. The patient needs help and is vulnerable.

You will develop your skills at eliciting the history as your career progresses. It can be depressing for a beginner to open a textbook on clinical history taking and to read that the history is the part of the clinical process which will deliver you the diagnosis. The ability to glean the diagnosis from the history is won by experience (and even then is not infallible: you may be experienced in history taking but the patient may not be experienced in history giving). At first you will not know what information matters and what does not. You will write too much; you will show a keen interest in everything the patient tells you, winning points as a good listener, but only because you are wide-eyed in a new land where you cannot read the road signs. Only slowly, as you come to know the many patterns of presentation which routinely come to your door, will you learn the language, the common cues from the patient's tale.

The history-taking conversation has an agenda. It is your job to pursue it. Establish a rapport with the patient quickly and direct the conversation to elicit the information which you need.

Ask who the patient is, how and when the injury happened, what effects it is having, what the patient has done to treat it and whether those measures have been helpful.

Ask about the patient's medical history, especially any aspects which have a bearing on the present situation. Remember that midline injuries are more easily confused with illness than limb injuries and that elderly patients often suffer injuries after a collapse.

At the start, use open questions. Do not direct the patient to one-word answers and do not suggest the replies that you expect. Listen and observe. Once the broad outline is clear, there will be an indication of what the problem may be. Ask clarifying questions, inviting brief factual replies. This should help you to make a differential diagnosis, a list of the possible causes of the patient's problem.

This is an ideal picture. It is only possible to direct the process skilfully if you have some idea where it is going. Some patients can be so talkative, or so monosyllabic, that it is a struggle to get useful information out of them.

The exact method of taking a history depends on who the patient is and the nature of the problem. Is the patient a child, an adult or an old person? Is the injury to limb or to midline? Is the patient sick, injured or suffering from an overuse injury?

The history of an injury

An injury is, as a rule, a sudden interruption of the patient's normal routine. Look ahead and anticipate any problems which the injury might provoke in daily life. Because it is a sudden and painful event the patient will normally be able to remember it and tell you what has happened.

Record the patient's age, gender and occupation. If there is an arm injury, is the patient right-handed or left-handed? Ask about hobbies. Depending on the context, ask about the domestic situation. Is there anyone at home? Are there stairs in the house? Did the patient drive to the unit? If so, is the patient alone? Who is present with a child?

Ask about any treatment which has been used so far by the patient for this injury, and any impression of its success or failure.

Injury is a mechanical process and the mechanism of injury (MOI), the way that the injury occurred, leads directly to the diagnosis. For example, the knee and elbow are both stabilised at the lateral and medial sides by structures called collateral ligaments. It is very common for a blow to the lateral side of the knee to tear the medial collateral ligament of the knee, but virtually unheard of for a similar blow to rupture the elbow ligaments. The difference is simply that the knee injury occurs when the body's weight is passing through the foot, and the knee cannot escape. The elbow can usually just fly away when struck in that manner.

'When', 'how', 'where', 'what', 'who' and 'why' are Kipling's **six honest men**, trusty questions which will get to the facts. Some will be more important than others in a given case, but three are always relevant: 'when', 'how' and 'where'.

When

Always establish the time of an injury. Healing occurs in stages and the same injury requires different treatment at different times. Similarly, the same symptoms, such as pain or the inability to walk, are of different significance if the injury is 2 hours, 3 weeks or 6 months old.

Test all the links within the patient's account of the timing of the injury, for two reasons:

- The time that it takes for certain signs and symptoms to emerge after injury, such as swelling or inability to walk, gives an indication both of the diagnosis and the severity of the injury.
- It is not unusual to hear a patient assert that the injury occurred on a given day and that the pain is a result, and then to discover that the pain did not come on until days, or weeks, after the so-called injury and that it has no connection to the incident.

The time elapsed since an injury is important when the patient has a wound. Policies for wound closure and the assessment of infection risks, including tetanus, are partly based on the age of the wound.

How

The central question about an injury is 'how did it happen?'. The answer to this question contains the facts about the MOI. It will help you to understand what structures the patient may have damaged. The question is so important that when a patient cannot say how the injury happened you must keep an open mind about whether or not an injury has happened.

Questions will relate to mechanical factors, speed, height, duration, direction and any other element which may have contributed to the injury.

In an ideal situation, the patient's replies will provide a reconstruction of the whole incident, so that you can 'see' the event as if it is a video replay.

The patient may not know how the injury happened but may offer an answer if you seem determined to have one. Do not lead the patient to describe the mechanism of injury which you think fits with the presentation.

Where

The place where a patient is injured matters because it contributes to the mechanism of injury. Whether a patient falls on grass or concrete, down a flight of stairs or out of a tree will influence thinking about the possible range and severity of injuries.

If a patient's hand is cut on waste ground where there is broken glass then there may be glass in the wound. The site will also influence an assessment of the risk of tetanus and other infections.

There may also be health promotion and legal issues around the question of where an injury happened. An employee may have been injured in a dangerous workplace, or a child may have found a syringe in a play park.

What

What caused the injury tells you about the possible extent of the damage. A craft knife with a 2-cm blade will not cause a deep wound. You can relate this information to the anatomy of the injured part to decide what underlying structures may be harmed. If the injury is an abdominal wound inflicted by a long, narrow-bladed knife then, regardless of how well the patient looks, an urgent surgical review is needed. If the 'what' is a piece of broken glass or torn metal, you can request a soft tissue X-ray to look for a foreign body.

Who

Sometimes, the question 'who?' is actually about the identity of the perpetrator of an injury. This may arise if a non-accidental injury to a child has happened. Sometimes it is a question about the other person's medical status, if, for instance, the patient has suffered a human bite wound. On other occasions, the question is an extension of the search for the mechanism of injury. How big was the person who fell on the patient?

'Who' may also cover other concerns. Was anyone present who can give an account of how the patient suffered a head injury? Who is at home to look after this patient if he or she is discharged?

Why

Some accidents are caused by events which are not likely to be duplicated. In other cases, an equipment flaw, poor workplace practice, a bad lifting technique, someone else's carelessness, overindulgence in alcohol or some other factor has contributed to the injury. The injury has not been a random event. In these cases there are three considerations. It could happen again, steps could be taken to prevent it from happening again, and there may be litigation.

'Why' can also be important if the answer to 'how' is in doubt. A common scenario is the elderly person who has had a fall. The patient may indeed have tripped, but there may be something else going on. The patient may have collapsed, and the cuts and bruises may be the least of the troubles. The first question is 'why did you fall?'. If the patient does not know, or if the answer suggests a medical cause, you must give this question priority.

The past medical history

Once the patient has given an account of the injury, ask about his or her medical history, particularly where there

are health issues which may influence your treatment and particularly when the patient is elderly.

TAM is a useful acronym which means tetanus, allergies, medicines.

Tetanus

If the patient has a wound (and this includes burns, splinters and eye injuries), always ask if tetanus immunisations are up to date (see Chapter 16).

Allergies

Ask about any allergic response to any medication or skin tapes such as Elastoplast. What exactly was the reaction (the patient may not know if it occurred in childhood)? Many patients who have difficulty tolerating a medicine for some reason believe incorrectly that this is an allergy. Occasionally, in cases where a history of allergy will influence your proposed treatment, you can contact the GP for more information. Do not give a patient a medicine if there is a possibility of allergy. The reaction may be more severe than it has been in the past.

Medical history and present medications

Many of the questions which you would ask a sick person (for example, family medical history) are superfluous when a patient has suffered an injury. However, major illnesses such as diabetes, heart disease, stroke or epilepsy should be recorded. Certain problems may be worsened by your treatment (such as using ice on the hands of a person who suffers from Raynaud's disease).

Think carefully about the patient's presentation if there is a history of cancer: is there a clear history of injury? Is the pattern of pain consistent with injury? Is the apparent severity of the injury consistent with the violence of the mechanism?

Ask about past orthopaedic, neurological and rheumatological problems when a patient has joint pain of uncertain cause. Ask about recent and present infections. There can be links between skin problems and arthritis.

Does the patient suffer from gastric or renal problems? Is he or she asthmatic? This is relevant if you are thinking of prescribing ibuprofen. Is the patient taking any medicines just now? Corticosteroids and anticoagulants should be specifically mentioned. Corticosteroids can cause decline in bone, soft tissues and skin, and they can mask serious infections and cause dangerous complications if the patient should need a general anaesthetic. Anticoagulants, commonly warfarin, can trigger excessive bleeding after an injury, particularly dangerous in the case of a head injury.

The clinical history for limb and midline injuries

Limb

Approach limb injuries in a structured manner:

- Is there a definite history of injury?
- If not, is there an explanation for an overuse injury: sport, playing a musical instrument, typing or other keyboard use or an intensive period of unaccustomed physical work (eg, gardening or decorating)?
- If not, could the patient be ill rather than injured?
- How will the injury affect the patient's daily life (right- or left-handed, able to walk, patient's home, job and hobbies)?
- Is the injury open or closed?
- When, how and where did it happen?
- What pattern of tissue damage does the mechanism of injury make possible? Does the history suggest a fracture, muscle tear (strain) or ligament tear (sprain)?
- If so how severe does it seem to be?
- If not, what other structures may be injured?
- Could the problem be with a non-musculoskeletal structure such as skin, nerve or blood vessel?
- Could limb pain be referred from the trunk?
- Will the patient's medical history have any influence on the possible injury or recovery?

Midline

The following are key points for assessing patients with injuries to the midline:

- Is there a definite history of injury?
- If not, is the history consistent with a common pattern of injury such as waking with torticollis?
- If not, could the patient be ill rather than injured?
- Is the patient in a vulnerable age group, very young or elderly, or vulnerable for some other reason such as learning difficulties?
- Are there guidelines for management of this type of injury? If so, structure the history to elicit key information; for example, how long after the incident did the patient feel pain from his or her injured neck?
- Does the patient have any systemic symptoms or history (eg, a loss of consciousness, headache, breathlessness, haemoptysis, haematuria, nausea, vomiting or weakness) which suggest injury to a major organ?
- Does the patient have any symptoms or history of problems local to the site of the injury (eg, tender midline of the cervical spine, surgical emphysema

on the ribs or bleeding from an ear) which suggest injury to a major organ?
- Do the patient's social circumstances make discharge a safe option?

The clinical history for children and the elderly

Children

Your assessment of a child should begin, where possible, before the child is aware of your presence:

- Where possible, observe a young child in the waiting room before calling him or her. Is the child playing normally, moving well and relating to parent or other carer in a spontaneous way?
- The child's carer will have a place in the consultation quite different from that of anyone who accompanies an adult patient. Observe the interaction between the child and the carer and establish a relationship with that person as well as with the patient. Record the carer's relationship to the child in your notes. Arrange things so that the child has the access that he or she prefers to the carer. For a small child this may mean sitting in the carer's lap. If the child is too young to tell you what has happened the carer may be your only source of a history.
- Is the child in pain? Early analgesia and a delay to allow it to take effect may make the consultation easier. Consider the value of splints, slings, ice and other aids for reducing the pain and anxiety of an injury. Children will usually prefer to have a wound covered so that they cannot see it. Distraction using films, moving lights, sounds and play can calm a child, reduce the impact of pain and give you a clearer idea of how the child is. Analgesia for children was discussed in Chapter 1.
- Respect the child's autonomy as much as is compatible with serving the child's interests. The maturity of the child, the degree to which anxiety is perceived to be influencing his or her behaviour and the wishes of the parent or carer are also factors. Let the child speak, answer truthfully and explain things in a way that suits the child's age and stage. You may find that you can demonstrate certain things on a teddy bear or similar toy, and you may be able to enlist the parent for this role. Children are usually worried about the prospect of injections or other painful procedures. You may be able to improve the situation by reassuring your patient but do not give false reassurance. The issues of the child's consent to medical treatment and the right to confidentiality, even against the parent's wishes, were discussed in Chapter 1.
- Your approach to a child will reflect the child's stage of development. If the child is too young to tell you a history then more weight is placed on other resources to reach a diagnosis: these include the carer's account of the problem, the scope of your physical examination, your use of X-rays (and possibly other investigations), your threshold for a senior or specialist medical consultation and your use of follow-up clinics and discharge advice as a safety net.
- Injury patterns in children are often different from those in adults. You must know the common possibilities and structure your history to elicit the relevant information. These differences will be described throughout this book. A child who has developed a limp with no history of injury should be discussed with a senior doctor or referred to a paediatric specialist, depending on your local policy.
- Is there anything in the story of injury or the social background of the child which suggests non-accidental injury or an unsafe home environment?
- Children in the UK benefit from a national programme of immunisations, including vaccination against tetanus. Recent immigrants, people who are outside our ordinary systems such as travelling communities and those whose parents withhold consent to immunisation may not be covered. The patient's tetanus status should be recorded if there is a wound, burn or eye injury.

The elderly

Investigate the small domestic, social and medical details of an elderly patient's daily life. They will shape your management plan even more than the injury:

- Do not rush. Be aware of basic communication. Can the patient see and hear you? Are you sitting with your back to a window so that your face is in shadow? Is there loud background noise? Patients who have fallen have sometimes lost or damaged spectacles or a hearing aid.
- Your first question with an older patient is whether the injury is linked to a medical event, a collapse. Does this patient appear to be fit and active or frail and vulnerable? This distinction has value but it is unscientific: it has to be confirmed by the outcome of each consultation. Record vital signs and look closely at the patient's medical history. Complete a dementia scale. Complete any other basic tests such as urinalysis and BM that

the history suggests. The context of the injury will guide you. If the patient has been injured while playing golf, hill walking or while out with the dog, an uncomplicated injury is more likely. An injury in the bathroom, a fall from a bed or chair, a fall in the street or injuries to the face with no injuries to the hands (suggestive of collapse) are more likely to be suspicious.

- Is there someone with the patient who can give some context to the patient's history? Did the patient come by ambulance? Read the ambulance notes. Do you have access to shared information, including GP notes, for this patient through an electronic portal? If not, consider a phone call to the GP. Have there been other visits to the emergency department or minor injury unit? Is there a history of falls?
- Ask for a detailed social history including who lives with the patient, stairs to and within the house and routine visits by relatives, friends and carers. Is the patient known to social services? If the patient lives in a nursing home, what level of support can it offer? Is the patient accompanied by a carer? Does the carer have a referral letter and a copy of care plans and prescriptions?
- Some elderly people are prone to injury without a collapse. Does the patient use walking aids? Visual or hearing impairment, problems with balance, arthritis, Parkinson's disease and a tendency to agitation are among the possible contributors to this risk.
- Ask if the patient has started any new medicines recently. Polypharmacy and side effects from medicines can create the conditions for an injury.
- Has the patient been acutely unwell recently? Is there any sign of a current infection?
- If the patient has suffered a head injury, no matter how minor, discharge will depend on a plan for support at home for at least a day after the injury. This is true for every patient with a head injury, but older people are vulnerable and many are alone and isolated.
- There will be a presenting problem but ask whether the patient has a new onset of pain or disability in any other part since the injury. Has he or she been walking since the incident? Your examination will also explore this question.
- If the patient has a wound, burn or eye injury remember that the UK's national tetanus vaccination programme was introduced in 1961. Older patients, especially women who are less likely to have served in the armed forces, may never have been immunised.

RECORDING THE EXAMINATION

In this section, the layout of the written record of a clinical examination is shown. The chapter closes with some fictional written records. These are workaday samples of common presentations and no claim is made that they are flawless. The examples may include some terminology which is new to you. These terms are all defined at the appropriate sections of the book. The important thing to grasp at this stage is the general method of presenting the information.

The written record is a contemporary one, written at the time of treatment, and the working day is busy. Notes have to be succinct. If they are not written during the consultation, important facts can be forgotten very quickly and the benefit is lost of the structure which the note can impose on the examination. Sitting in front of the patient and writing what is more or less a summary of the whole interaction can also help you to put ideas in order and to reach a decision about how to proceed.

Layout

There are variations on the recommended layout and it has to be adapted for different types of presentations but the basic pattern of the notes is universal. The first two parts are based on things that the patient relates. The rest of the note records the process of your examination and the actions which flow from it:

- The 'history of the presenting complaint' (usually labelled as **HPC**; **C/O,** meaning 'complains of', is also used): this part will begin with some bare details about the patient (gender, age, job, right- or left-handed) and the injury. This is what the patient relates, edited to what you consider to be relevant, but still, essentially, the patient's words.
- The patient's 'past medical history' (**PMH**): current medicines, allergies to medicines and, if there is a wound, tetanus status.
- The examination (**O/E** for 'on examination'): the structure of the examination depends on the type of problem (often you will follow the orthopaedic method, 'look, feel, move' described in Chapter 5). All general observations, all examination techniques and any significant findings, positive and negative, are recorded.
- An 'impression' (**Imp**) or provisional diagnosis.
- Investigations (most commonly X-ray).
- The results of investigations.
- A final diagnosis: if you cannot make a diagnosis record the conclusions that you have reached so that there is a rationale for your management plan.

- Your final management plan: this may include treatment, discharge, referral, review by you or someone else at a later date, advice to the patient on care of the problem and where to go if it worsens and any other steps needed to complete the process.

Send the GP written notification of the important details of the patient's visit. Each area has a process for doing this. Give the patient a copy of the notes or a letter if a referral elsewhere is made.

Case studies in writing a history

Case studies 2.1 and 2.2 are histories from patients who are injured in ways that are superficially similar, ways that sound the same judging by the words that the patients use, but differ in the key point, the diagnosis. These injuries sound the same because the two patients describe two different mechanisms of injury in the same common, vague, everyday language. Press beyond the first words to a clearer picture of what has happened. In Case study 2.1, the likely diagnosis, with that mechanism and that presentation, is a fracture, while a sprain is more likely in Case study 2.2. Injuries tend to fall into patterns. Most ankle injuries are caused by an inversion mechanism. If the patient is vague in the description of the incident, and most patients are vague in this way, you will overlook the exceptions to the ordinary pattern if you do not ask the next question. In these two studies, you would have been likely to arrive at the correct diagnosis regardless of the assessment of the mechanism because an X-ray would probably be requested in both cases. You will not always be so lucky if you lack enquiry. Two further case studies (2.3 and 2.4) illustrate the recording of two other types of injury.

Case study 2.1

Patient is a 20-year-old man who works in an office. He lives at home with his parents.

He was playing football an hour ago. He jumped up to head the ball and collided in the air, shoulder to shoulder, with another player. He fell on his left side. The other player fell heavily across his right ankle as the foot lay, outer side up, on the ground. The man heard a crack and felt sickening pain in the outer ankle. He was unable to walk. His teammates carried him off and put an ice-pack on the ankle within 10 minutes. He was brought straight to the hospital. He is in a wheelchair. He is pale and there is a large, bruised swelling over the outer ankle.

Written record

HPC: 20 yrs man, office worker C/O 'twisted ankle'.

Brought by friends in a car.

Lives with parents, ground floor flat.

Football, 1 hour ago.

Pt on ground on left side. A player fell across his right ankle, *eversion.* Heard 'crack'. Immediate pain. Swelling at outer ankle. Non-weight bearing since. Has used ice. Can feel/wiggle his toes.

PMH: No allergies, no medications. No asthma, gastric, renal problems.

O/E: Right lower leg/foot

Pt looks pale with:

- large, bruised swelling over lateral malleolus
- no deformity
- sensation and circulation to foot intact
- tender distal fibula; no tibial tenderness
- all ankle movement restricted by pain at lateral ankle.

Imp: fracture of distal fibula.

Investigation: X-ray lower leg and ankle.

X-ray: fracture distal fibula, no talar shift.

Plan: orthopaedic review.

Case study 2.2

Patient is a 20-year-old man who works in an office. He lives at home with his parents.

He was playing football an hour ago. He jumped up to head the ball and collided in the air, shoulder to shoulder, with another player. He landed awkwardly on his right foot and felt the ankle twist inwards, sole of foot turned towards other foot. He heard a crack and felt sickening pain in the outer ankle. He fell to the ground. He has not been able to walk. His teammates carried him off and put an ice-pack on the ankle within 10 minutes. He was brought straight to the hospital. He is in a wheelchair. He is pale and there is a large, bruised swelling over the outer ankle.

Written record

HPC: 20 yrs man, office worker, C/O 'twisted ankle'.

Brought by friends in a car.

Lives with parents, ground floor flat.

Football, 1 hour ago.

Pt jumped 2 to 3 feet, came down on right foot, 'twisted ankle' (shows inversion). Heard 'crack'. Immediate pain. Fell and was carried off. Non-weight bearing since. Swelling at outer ankle. Has used ice. Can feel/wiggle his toes.

PMH: No allergies, no medications. No asthma, gastric, renal problems.

Continued

Case study 2.2—cont'd

O/E: Right lower leg/foot

Pt looks pale with:

- large bruised swelling over lateral malleolus
- no deformity
- sensation and circulation to foot intact
- tender inferior aspect lateral malleolus; no tenderness at base 5 MT
- all ankle movement restricted by pain at lateral ankle.

Imp: Sprain, but exclude fracture to base of lateral malleolus.

Investigation: X-ray ankle.

X-ray: No fracture.

Further examination: Anterior drawer test of ankle; pain but no marked ligament laxity.

Diagnosis: Sprain, likely to be grade two.

Plan: Has transport:

- Home on crutches to parents.
- Has paracetamol – full advice on dosage and side effects.
- Rest, ice and elevation regimen discussed, advice leaflet given.
- Physio tomorrow 1100h, full ligament assessment and treatment.

MT, metatarsal.

Case study 2.3

Patient is a 45-year-old man who complains of a cut to the head.

He is an engineer. He is married with two grown-up children living at home.

An hour ago he was in the boiler room in the bakery where he works. He ducked under a pipe to reach the boiler. He forgot the pipe when he stood up and banged the top of his head on a metal bracket. Pain made him dizzy for a moment but he did not lose consciousness or fall to the ground. He did sit down for a few minutes. He felt better but his head was throbbing around the spot where he hit it. He touched his hair and saw blood on his fingers. He went to his first-aider who bandaged his head and brought him to hospital.

Written record

- *HPC*: 45 yrs, man, engineer in a bakery:
  - Lives with wife, 2 adult children. Wife home now.
  - Brought by a workmate in a van, he is in the waiting room.
  - 1 hr ago stood up under a sharp, dirty metal pipe bracket, painful blow and laceration to top of head.
  - Brief dizziness, resolved now, headache local to injury only, 'throbbing'.
  - No LOC (loss of consciousness), neck stiffness, vomit, amnesia, vertigo, nose/ear discharge. Walking well, no loss of power/sensation in limbs.
  - Wound is bandaged, has not been cleaned.

PMH: Tetanus – booster 2 yrs ago. No allergies. No medications.

O/E: Head

1. Neuro:
   - GCS 15 (Glasgow Coma Scale; see Chapter 12). Looks pale but fully mobile and responsive.
   - Cranial nerves II–XII normal.
   - FROM (full range of movement) neck, no midline tenderness at the back of the neck, no paraesthesia or weakness in limbs, reflexes equal.
2. Wound:
   - 2 cm transverse lac, in left parietal area.
   - Not full thickness, no haematoma, bone smooth and firm.

   Imp:
   1. Minor head injury.
   2. Wound for clean and closure.

   Plan:
   1. Phone home. Pt home to wife (has a driver). Discussed HI (head injury) advice sheet with her. Return if problems.
   2. Wound toilet with saline. No dirt.
   3. Two staples to close. Staple advice sheet. GP if any infection signs.
      Practice nurse in 5/7 for ROS.

ROS, removal of sutures.

Case study 2.4

Patient is a 23-year-old woman, a right-handed, self-employed picture framer who runs her own shop single-handed. She complains of a cut to her right hand.

She was carrying a sheet of picture glass when she tripped and fell, breaking the glass and pressing her right palm onto the shards. She has a cut over the muscle pad of her thumb. It looks deep and is bleeding very freely. She wrapped a scarf tightly around her hand and called a taxi to take her to hospital.

Written record

HPC: 23 yrs woman, right-handed picture framer, self-employed, works alone.

1 hr ago, carrying picture glass, fell on top of it, cut right palm on broken glass.

'Heavy' bleeding, not pulsing. Pressure dressing improvised, bleeding controlled. 'Could be' glass in wound.

PMH: Tetanus – booster at school, ? 7 years ago. No allergies, no problems with lidocaine, no medications.

O/E: Right hand:

- Diagonal 1 cm cut in middle of thenar area.
- Wound mildly tender, no focal areas of sharp tenderness.
- Sensation intact.
- Bleeding, moderate oozing.
- Penetrates to fat, no visible deeper structures.

Imp: ? glass in wound.

Investigation: soft tissue X-ray hand.

X-ray: no radio-opaque foreign body.

Further examination: resisted movement strong/pain-free in thenar muscles and flexors of the thumb and index finger.

Imp: no foreign body and no structural injury found as yet. Wound for cleaning and exploration under local anaesthetic. If all clear, closure.

Plan:

1. Local anaesthetic.
2. Wound toilet with saline, wound explored. No deep damage seen.
3. 2 × 4.0 prolene sutures to close. Dry dressing.
4. Suture advice sheet discussed. GP if infection.
5. ROS in 10/7 by practice nurse.

   Note: The local anaesthetic prescribed would be recorded in a separate part of the record.

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Chapter 3

X-rays and the non-medical referrer

CONTENTS

X-RAYS

X-rays are visual images, pictures that show us things that are inside the body, under the skin. This remains a radical capability even after 120 years and even though the images still have an old-fashioned look: they are like the negatives of old black-and-white photographs. And, in fact, they are negative images. This explains certain odd things: the word 'lucency', which means 'light', is used in radiology to describe the black background that appears between two separated fragments of broken bone. But if the image is a negative, light is seen as black and darker objects look white.

X-rays are radical in other ways: they are visually radical. In fact, the dark areas on an X-ray image do not represent light. X-rays look familiar, visually, but they are less so than they seem and we can make incorrect assumptions when we look at them. The light and dark areas in a negative from an old black-and-white photograph take their tones from the distribution of light and colour in the picture. The distribution of tones in an X-ray is governed by other factors.

Ordinary pictures tend to create an illusion of space, of three dimensions captured in two, because they mimic the way that we see distance in the three-dimensional world. If a colour is bright or a line is sharp or heavy and dark, it appears to be near: things that are far away look hazy and washed-out, nearer to grey. Things also get smaller as they go back in space, as diagonal perspectives diminish to a 'vanishing point'.

X-rays do not give us much spatial information, and they can be positively misleading. The rule for an X-ray is that the beam of radiation will hit the film plate and burn it black if nothing gets in the way. In other words, the black area on the negative, which represents light in a photograph, represents air in an X-ray. If something very dense, such as lead, gets in the way of the beam, then no radiation will pass through and the plate will remain white. If the beam passes through human fat it loses a little power and the plate takes on a grey imprint of the fatty area. Muscle is more dense than fat and will leave a mark nearer to white. Bone is still more dense, and the mark will be whiter still. The thicker the bone, or if bones are overlapped, the whiter will be the image because less radiation passes through to the plate. This means that brightness in an X-ray image is related to density of tissue, not to light or the fact that something is nearer to us in space.

The X-ray image is also a composite of everything that the beam has passed through. This means that structures which could not be seen by the naked eye if we were able to see the patient's skeleton are visible and superimposed on one another on the flat X-ray plate: your eye will try to make spatial sense of this, to see one structure as nearer or further than another, but the X-ray does not give you that information. When you look at a lateral image of the ankle you see the fibula superimposed on the tibia but you cannot tell from which side of the foot the image was taken.

When you look at an X-ray of the face you see two large, dark hollows above the eyes and two more below the cheekbones. If you compare this image with a skull you see that these hollows are not accessible or visible on the surface of the face: a thin plate of bone, so thin that the X-ray beam hardly registers its existence, covers them. The picture shows you the deeper parts but not the external layer, solid though it is, a selection based entirely on the relative densities of the surfaces.

To apply this clinically, think of a patient who has fired a nail gun through the centre of his foot. The patient arrives with a nail whose head is visible on the top of the foot, sticking out of his bootlace, and whose point is embedded in the sole of his boot. A soft tissue X-ray of the lateral foot will show the nail as brilliantly white and it will look as if

it is lying on top of the bones, just under the skin. We need a second view from front to back of the foot to show us that it passes through the centre, in the middle of the tarsal bones, and is probably in a joint. The lateral image is not telling us where the nail is, but it *looks* as if it is. In fact, the brilliant white of the metal obscures the grey image of the tarsal bones which actually lie on top of it.

Perspective is also of little value in X-rays because the distances involved are small. The image is only as deep as a human body.

This means that there are two reasons why we usually require two images of every injury. One is to see the injured bone in the round, to increase our chances of spotting an injury which might be concealed on one view. The other is to help us to correlate the spatial clues, to get a 'fix', especially on foreign bodies, but also sometimes on puzzling fragments of broken bone, in the two images.

THE NON-MEDICAL REFERRER

As emergency nurse practitioners (ENPs) you will refer patients for X-rays on every working day. 'Have I broken my … ?' is the commonest clinical question asked by patients with minor injuries. X-rays penetrate the skin and give us a detailed image of the bones. They allow us to answer the patient's question: or rather, they *usually* allow us to answer the patient's question. They also show us objects from the outside world if they happen to have found their way into the body through a break in the skin or through an orifice and if they are dense enough to be conspicuous on the image.

The authority to request X-rays was once reserved to doctors. The expansion of this permission to include ENPs and other groups has come along as new roles have emerged in healthcare. This expansion is controlled by law and by employer policies because X-rays are hazardous to patients. The law designates you as a **non-medical referrer** for imaging. In this context 'non-medical' means a registered health professional who is not a doctor. The decision to refer a patient for an X-ray involves weighing the potential clarification that the image may bring to the diagnosis with the hazards of the exposure and also with its value in changing the management of the patient's injury. This chapter deals with the rules for X-ray requests by ENPs. It will also introduce some basic concepts for the interpretation of X-rays.

IR(ME)R and the ENP

Your authority to request X-rays is ultimately derived from parliamentary regulations that are enforced under the criminal rather than the civil law. Your employer is bound by the same regulations to create the local policies under which you operate. You are also obliged in this, as in all professional matters, to meet the standards of the Nursing and Midwifery Council (NMC). Three points are relevant:

- X-rays are, like almost every medical intervention, a compromise between risk and benefit to the patient. The risk from X-rays, from the toxic effects of radiation on the body, is so significant that the authority to request them is given by law. You must know the key provisions of the **Ionising Radiation (Medical Exposure) Regulations 2000** and the **Ionising Radiation (Medical Exposure) Amendment Regulations 2006 and 2011**, usually called the **IR(ME)R** regulations. This chapter will explain the main points of the law as they apply to you.
- The use of certain dangerous investigations and treatments has always been an integral responsibility for the medical profession: its governance was incorporated into the structures of that profession and the law on these matters has always been written with the medical profession in mind. The transfer of medical roles to nurses and to other groups means that we have needed new mechanisms for governance and patient safety at every level from local policy to parliament. IR(ME)R is the legal foundation for you, the ENP, a 'non-medical referrer' requesting X-rays for your injured patients. Not only must you understand IR(ME)R, you must fulfil IR(ME)R's requirements for you to become a referrer. These requirements are in part decided at a local level, but there is a good deal that is common to us all and this chapter will describe the broad conditions you must meet under IR(ME)R to become a non-medical referrer of patients for X-rays.
- The traditional nursing role has always involved activities which are dangerous for patients and sometimes for you. You work in a risky environment and you are accountable in every moment, for every action, to nursing's governance structures. This does not change when you become an ENP. You must continue to satisfy the requirements of your Code of Conduct and the local policies which apply to the nurses in your area. You have taken on a role that was once medical but that does not make you a professional 'in-betweener': you are still a nurse. You must be listed on the NMC register in order to practice and the ethics and obligations of a nurse still apply when you undertake a new role such as ENP with extra functions such as the requesting of X-rays.

Patients with minor injuries may need X-rays for possible fractures, dislocations or **radio-opaque** (meaning 'visible on X-ray') **foreign bodies** (**ROFB**) within wounds or natural openings. Most of these images are of the limbs.

To be a non-medical referrer in minor injuries you must be qualified through a recognized course stipulated by your

local IR(ME)R Approval Committee, to elicit a clinical history and examine the patient before you can refer him or her for X-ray: you must also understand your responsibilities as a non-medical referrer to your imaging services, and you must have knowledge of the relevant legislation, professional guidance, local policy, training requirements and the roles of the different participants in the process.

IR(ME)R offers statutory direction for all professional participants in procedures which expose the patient to radiation. Potential radiation harm is variable and is influenced by the type and dosage of exposure. Effects can include cancers, anaemia, damage to DNA, burns, cataracts, sterility and hereditary defects. Damage to the unborn child can occur, and IR(ME)R emphasizes the care and protection of the pregnant female.

Patients may be exposed to medical radiation (the other types of radiation are described as 'occupational' and 'public') for different reasons, including therapy and research, but in the case of ENPs, the reason for exposure is invariably to help with diagnosis and X-ray is the only form of imaging that is requested. The dosage of radiation, according to the Royal College of Radiologists (RCR), received by a patient for a limb X-ray (excluding the hip) is less than 1.5 days of natural background radiation (for a chest X-ray it is 3 days). The dosages we are discussing for most of the requests by ENPs are therefore relatively low. However, the dosage received for an X-ray of the hip is 2 months, for the pelvis 4 months and for the lumbar spine 5 months. These figures pale in comparison to the dosages received during the larger computed tomography (CT) examinations (4.5 years for a CT of the abdomen). It is also the case that the use of CT scanning is increasing and that of plain X-rays falling. Nonetheless, there is a significant difference between the smallest and the largest exposures to plain X-ray radiation, in terms of dose, in terms of the vulnerability of different parts of the body to ill effects and in terms of the increased risk to certain patients compared to others.

The discussion of IR(ME)R that follows is directed to those aspects that are relevant to you, the ENP, and to your use of X-rays for diagnosis of patients with minor injuries.

IR(ME)R specifies the obligations of four groups:

- The **employer**, normally represented in legal terms by the Chief Executive and the board of the health organization, has a role as overseer of the health and safety aspects of imaging. The employer will put in place a framework of written standard operating procedures to keep patients safe when they are exposed to medical radiation. Local policy will be embodied in these guidelines and will cover the activities of all of the professionals who are involved in the process. They will specify processes for identifying the patient, listing referrers and protecting females of child-bearing age. They are also responsible for setting up quality assurance procedures and notification of incidents where patients suffer excessive exposure. Before you, the ENP, can practice, the employer must authorize you individually, in writing, to request X-rays, must stipulate which views you can request and must be satisfied that you have completed a prescribed programme of training for this role.
- IR(ME)R uses the term **practitioner** for the person who confirms that any given exposure is *justified* in terms of the balance of benefit and risk for the patient. This justification must take place before the exposure is allowed. A practitioner is a registered health professional, usually a radiologist, although the role is often delegated to radiographers for patients who require plain X-rays, who can interpret the clinical information provided by the referrer and relate it to the imaging options that are available.
- Once it is confirmed that an exposure is justified, an **operator**, usually a radiographer, will create the image and ensure that the requirements for justification have been met. The operator will ensure that the dose of radiation to the patient is *as low as reasonably practicable (ALARP)*. The operator will manage the technical aspects of making the image including positioning the patient and the equipment. The operator will also issue a report interpreting the image.
- Referrers, healthcare professionals registered with a body recognized by the National Health Service Reform and Health Care Professions Act 2002, will provide the justification for the procedure based on a clinical assessment of the patient. Referrers are selected locally by a combination of the employer and the IR(ME)R Approval Panel, a group made up of radiologists and other imaging professionals for that area. The Approval Panel will reach an agreement which will be issued in writing for each group of referrers. Your permission as a non-medical referrer to request X-rays is defined and limited by the scope of this agreement. The document includes a list of all of the referrers who are entitled to request X-rays. This list is available to the X-ray departments and it must be kept up to date. Your agreement stipulates the training that is required before you can refer patients for X-ray. This includes training in clinical history taking, examination, diagnosis, management of patients with minor injuries and specific training in IR(ME)R. You are a duty holder under the legislation and you must be aware of your obligations. There must be a record so that the training can be verified.

As a referrer you must know the criteria for justification and must take into account the procedures put in place by the employer, including clear identification of the patient and information about possible pregnancy. You must have

a specific understanding of IR(ME)R and the risks associated with exposure to radiation. Your role as a referrer must be included in your job description, as a part of your scope of practice.

As a registered nurse undertaking an advanced role you must be aware of and comply with all requirements of the NMC for that role. You must understand your scope of practice and your accountability to your profession and to the law for your actions.

As a non-medical referrer of patients with minor injuries you will provide your radiographer with a written request for a series of images. The process for making the request varies from place to place depending on the technology in use but the general principles are the same. You will supply patient demographics so that the patient can be identified and the images properly stored and retrieved. You will provide justification for the exposure by detailing the patient's complaint, the clinical signs of injury and the diagnosis you wish to confirm or exclude. You will supply information where relevant on patients who are females of child-bearing age. You will sign the request if it is handwritten, and comply with the precautions for identification and confidentiality that are contained in any computerised request system.

Once the images have been provided you will review and interpret them in the light of the patient's clinical presentation. You will record your finding and incorporate it into your diagnosis and management plan.

The radiographer who has exposed the image will also report his or her findings, and a radiologist will make a further, final report at a later stage, in writing. This report is the definitive opinion that the X-ray referrer has requested. There will be a mechanism in place in your clinical area to review the radiologist's report and to highlight any cases where there is disagreement with your finding (a so-called 'non-concurrent' report). There will also be a mechanism by which the patient can be contacted and informed of this development and offered any treatment that the change in diagnosis implies.

Audit of the effectiveness of this service must be continuous and review of the referral process should take place annually.

The RCR has issued guidelines that, among many things, inform the process of non-medical referral, 'Making the Best Use of Clinical Radiology Services'. Access to RCR guidelines is available through its website iRefer (http://www.irefer.org.uk/).

REQUESTING X-RAYS

> ***'Referral for an imaging examination is a request for an opinion from a specialist in radiology'.***
>
> (RCR 2007)

As an ENP you will request X-rays, within the limits of your IR(ME)R agreement, when the possible diagnosis is a fracture or dislocation, or when the patient has a wound that may contain an ROFB, and *where the finding on the X-ray will make a difference to your management of the patient*.

Certain aspects of the request have been discussed in the section on IR(ME)R. The issue of possible or actual pregnancy in a female patient must always be considered.

The X-ray request is made in writing, either by hand or on a dedicated computer system. It must be accurate and legible. The patient must be clearly identified by name, date of birth and other available demographics such as address, Community Health Index (CHI) number and hospital or emergency department number. A well-written request will have three things in the clinical information box:

- The patient's mechanism of injury (for example, 'inversion right ankle'). Be specific and accurate on matters such as right or left, which finger and other relevant information.
- Your findings on examination (for example, 'swollen, bruised lateral malleolus, tender posterior margin distal fibula, reduced ankle movements, non-weight bearing').
- The diagnosis you wish to confirm or exclude (for example, '? fracture right lateral ankle').

The radiologist has the responsibility, as an expert on the interpretation of diagnostic images, of issuing a final report on the X-ray. Remember when writing your referral that the radiologist is the only person who is asked to comment on the image without having access to the patient. X-ray interpretation is not an isolated skill; it is guided by the findings from the examination of the patient. Imagine that you are writing your request directly to the radiologist and tell him or her every relevant thing. If the radiologist sees something suspicious on the image but notes that you have examined the part and found it to be normal, that may prevent an unnecessary recall of the patient.

INTERPRETING X-RAYS

An X-ray beam is absorbed to a different extent by different tissues. It simply passes through air and other gases, and this shows on the image as a black area. The image becomes lighter as the penetration decreases. Fat is dark grey, denser soft tissues such as muscles are a lighter grey, and bone and calcified tissues are nearer to white.

Where bone is broken and the damaged ends are separated, the gap between them has the same tone as the background, which is usually darker than the bone. The fracture is therefore shown by a dark line, a **lucency**, between the broken pieces (Fig. 3.1).

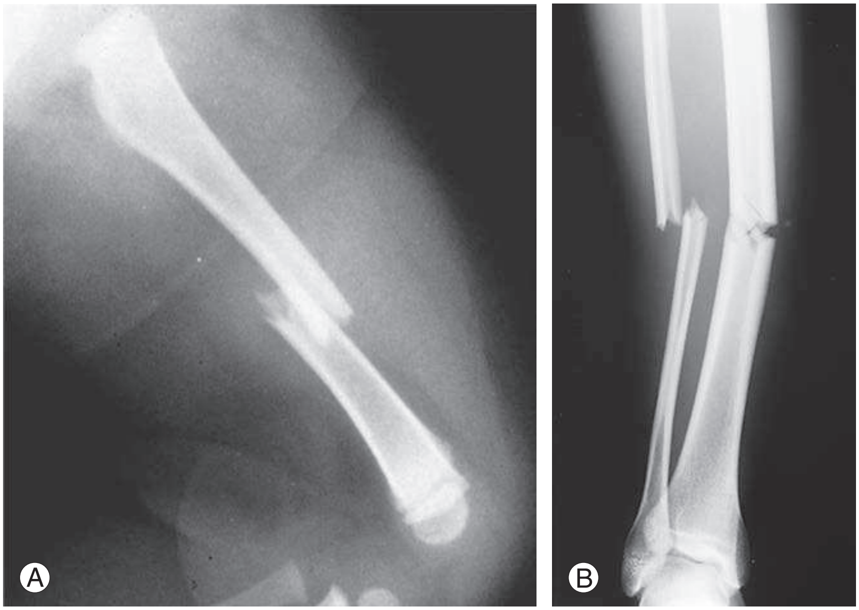

Fig 3.1 (A) Sclerotic and (B) lucent appearances on X-ray.
Source: From Marx, J., Hockberger, R., Walls, R., 2006. Rosen's Emergency Medicine, sixth ed. Mosby Elsevier.

If the bone is broken and the image shows the broken parts as overlapping, the area of overlap will look whiter than the rest of the bone because it is doubled in thickness and increased in density. The white area is described as **sclerotic**, meaning thicker than the surrounding bone (see Fig. 3.1).

The number of X-ray views required to exclude an injury varies but it is a general principle that two images are required and, where possible, these are done from front (or back) and from the side, a lateral image. In some cases, such as the hand, a lateral view is not the standard second view because the bones being studied are too overlapped for useful interpretation and an oblique image is exposed instead. The oblique image is projected to show the full outline of as many of the bones as possible but it cannot show every aspect of the bones so well as the optimum combination of frontal and lateral images. It represents a necessary compromise. Do not request hand views for finger injuries (unless the injury is near to the joint with the metacarpal bone) because fingers can be separated and X-rayed in a true lateral position.

Many fractures or dislocations are not visible on one of a pair of X-rays while they are plainly seen on the other (Fig. 3.2), so that it is almost always the case that two views are the minimum. Occasionally (the clavicle is an example) a single view is enough and in some cases where a fracture may be difficult to see, extra views are done (the scaphoid is the commonest example).

It is important that you request the correct views to show the area where the injury is suspected. The images for each area are intended to show that part optimally, to place it in

Fig 3.2 (A) An anteroposterior (AP) view and (B) a lateral view of a finger. One view is one view too few.
Source: From Raby, N., Berman, L., Morley, S., de Lacey G., 2005. Accident and Emergency Radiology: A Survival Guide, second ed. Saunders.

the centre of the image and to show it at the angle that is most revealing. You will risk missing the diagnosis if you are inaccurate. The choice of appropriate views to show a particular part and a particular injury belongs to the radiographer: it rests with you to give enough clinical information for an informed choice to be made.

In addition to standard signs of fracture, other X-ray evidence of a possible injury may be taken into account at specific sites, such as **fat pads** at the elbow or a fat–fluid level in the knee. These will be discussed in the appropriate parts of the book.

It is not always the case that the X-ray will settle the question that you are asking. In the end, it is an aid: the clinical management of the patient is based first of all on the clinical presentation. You will often return to the patient and re-examine him or her when you have seen the X-ray and you will rule out suspicious appearances on the image by finding the examination to be normal. The radiologist will often report on a suspicious appearance on an X-ray and advise this kind of **clinical correlation**.

When you are viewing the X-ray check that you have the correct patient and the correct image. The Picture and Archiving Communication Systems (PACS) may be storing images from other visits by this patient. If there are old images of the same body part that you have just X-rayed, remember that they may be useful for comparison with the present image but make sure that you do not mix them up.

View each image systematically: is the X-ray properly **adequate** and **aligned**, is the **bone** intact, is the **cartilage**, shown by the joint spaces normal, and are the **soft tissues** normal? This is the **ABCs** method for looking at the X-ray:

- Adequate: has the correct side of the correct patient been X-rayed? Do we have the best views for the injury in question and is the patient properly positioned? Have you excluded every diagnosis that the patient's mechanism of injury can cause?
- Alignment: rotation or any non-standard projection of the X-ray can obscure the injury. Is the patient's position optimal for that examination? If the foot is slightly rotated for an anterior-posterior (AP) ankle X-ray the lower tip of the lateral malleolus tends to overlap with the calcaneus and the space between talus and tibia becomes difficult to assess, both important features of your review of the image. If you have concerns about the quality of the image discuss them with the radiographer but approach the matter tactfully. There can be prohibitive difficulties in obtaining some X-rays, especially if the patient is elderly, young, intoxicated or in great pain, or if there is any other reason why cooperation is not easy to obtain.
- Bone: follow the external margin of every bone on the images. It will show as a white outline, the cortex (the solid outer shell of the bone). A gap in the cortex indicates a fracture. There may be extra density to the bone, a sclerotic area, indicating impaction or overlap of two broken ends. If several similar bones are present in the image, such as the metacarpals in a hand X-ray, or if the same bone on the opposite side is shown, as it is in views of the face, ribs, pelvis and hip, compare them. There will be a kinship in their outlines. Be wary of any jagged change in the angle of a bone. Bone tends to make transitions smoothly, with rounded corners and without sharp angles. There should be no splinters at the margin. The inner area of a bone will sometimes show a pattern of struts, like the girders of a bridge: like the girders these struts are designed to carry a load while remaining light. They are the cancellous inner layer of the bone. They, given their function, are always straight. In X-rays of the heel and of the neck of the femur, interruptions in the alignment of these **trabeculae**, or changes in their direction, can betray a fracture. Make full use of all views. If one view arouses suspicion, look at the same area on the other view.
- Cartilage and the joint: where bones are paired below the elbow and the knee, be aware that there are patterns of combined injury, either a double fracture or a fracture with a dislocation, and be prepared to request views from the joint above the injury to the joint below. There is a similar tendency to combined injuries in the mandible. Injuries to the joint itself include dislocation and subluxation, and a malalignment of the joint may also be seen if there is a large ligament injury. Narrowing of the joint can be seen if there is wear of the cartilage, and this indicates the degeneration that proceeds to arthritis. An inability to position the joint properly for an X-ray can occur because torn cartilage is obstructing the patient's normal movements.
- Soft tissues: X-rays to exclude radio-opaque foreign bodies must be specifically requested as **soft tissue views.** There will always be a lateral view designed to show the space between the skin and the cortex of the bone at the entry point of the wound, and this view is the one that is most likely to reveal a foreign body (Fig. 3.3). Remember that not every foreign body will show on X-ray. Glass and metal are the most commonly sought materials. Fish bones and tooth fragments are common biological materials which are also sought. If you are unsure whether a suspected material will be seen, discuss it with the radiographers. Remember also that ultrasound is an option for locating non-ROFBs. The soft tissues are visible as a pale outline, greyer than the bone, on an ordinary X-ray (to exclude injury to bone), and their condition, especially if they are swollen, is an indication of possible severe injury. This is a useful aspect of interpretation of an X-ray of the cervical spine but it has general application.

Fig 3.3 A soft-tissue X-ray with glass in hand.
Source: From Blakeley, C., Khaliq, W., Hashemi, K., 2008. Portable Ultrasound Diagnoses Flexor Tendon Sheath. Injury Extra 39, 323–324.

X-ray interpretation requires experience. Many things seen on X-rays look like fractures but are not. Some common situations are described here. Remember the value of clinical correlation: if the X-ray is suspicious but the patient is normal on examination a new fracture is less likely. Also remember in this situation, as in every professional situation, that you are part of a team – seek advice from your colleagues:

- Old, healed fractures may have left a fragment of non-united bone behind: how can I tell if it is old or new? Radiologists advise you to think of the effects of the sea on the pebbles on a beach when this question arises. Pebbles are worn smooth and round by the constant action of the water. An old fragment of bone will have a soft outline and a complete cortex. There will be no jagged edges or sharp angles.
- Occasionally you will see calcified areas which are not pulled away from the bones, but have formed in the soft tissues or the blood vessels. These tend not to have the density of the neighbouring bone, and their shapes suggest deposits rather than broken structures. In minor injuries a calcification of the tendon of the supraspinatus muscle at the shoulder is often seen.
- Elderly patients, young patients who have played a lot of field sports and patients with various joint diseases may have joint changes caused by wear or pathology: new bony growths, abnormal joint spaces and bone relationships, and crumbly fragments on their X-rays can complicate interpretation of the image.
- Patients who have undergone orthopaedic surgery may reinjure the same site and be concerned that they have done fresh harm. You may not be confident that you will be able to tell if the X-ray appearance is normal for this patient. You can compare today's images with any X-rays available from the time of surgery and you can contact the surgeons to discuss the patient.
- You may also see any one of a multitude of **normal variants**, anatomical quirks and harmless changes which appear on X-rays and cause confusion and misdiagnosis. Sesamoid bones, bones that are implanted in tendons (commonly patella and the sesamoids on the flexor side of the big toe), are sometimes divided (bifid) and this can mimic the appearance of a fracture. Diagonal grooves on the shafts of the phalanges of the fingers, so-called **nutrient lines**, can look like spiral fractures. Apophyses, attachment points on children's bones for muscles, have a growth plate between them and the rest of the bone which shows as a lucency on X-ray can cause confusion, especially at the base of the fifth metatarsal. The 'Atlas of Normal Roentgen Variants That May Simulate Disease' (Keats & Anderson 2013) is a large volume which you should be able to consult in your X-ray department for guidance on these questions. It is a book which is paid the genuine tribute of always looking well-thumbed.

If you see a fracture on an X-ray you will have to make a report upon its presence and its essential features. Your view of the significance of those features will guide you in the management decisions that you make with the patient.

In making your management decisions you will aim to give the patient good advice and accurate and timely treatment so that healing will be optimised. The first decision that you will make is whether the patient has an injury that requires urgent surgical management. If the injury is less urgent you will go on to make other decisions about immediate treatment and later follow-up.

Certain general aspects of a fracture will be mentioned here which may increase or decrease your concern:

- **Angulation**: this means that the bone is not only broken but also bent at the site of the break. The presence of angulation raises the question of whether or not the change requires correction. Angulation is actively treated in some cases and not in others (Fig. 3.4). The injury in the figure is a greenstick fracture and there is every chance that it will **remodel**, straighten out, with no active treatment except rest in a cast.
- **Intra-articular**: a fracture which passes into the joint has implications for future movement in the joint and for healing of the injury, and may need surgery to retain a smooth surface (Fig. 3.5). The injury shown is a Harris–Salter 4 fracture, with

Fig 3.4 A greenstick fracture.
Source: From Raby, N., Berman, L., Morley, S., de Lacey, G., 2005. Accident and Emergency Radiology: A Survival Guide, second ed. Saunders.

Fig 3.5 An intra-articular (Harris–Salter 4) fracture.
Source: From Kowal, D., 2007. Learning Radiology, Recognizing Fractures and Dislocations, Elsevier.

disruption of a young person's growth plate, and requires immediate orthopaedic referral.

- **Comminution**: if a fracture is in more than two parts anatomical positioning and healing may be much more difficult, and parts of the bone may lose blood supply (Fig. 3.6).

Fig 3.6 A 'three-part' fracture of the proximal humerus.
Source: From Raby, N., Berman, L., Morley, S., de Lacey, G., 2005. Accident and Emergency Radiology: A Survival Guide, second ed. Saunders.

Fig 3.7 Bennett's fracture: the tendon attachment at the base of the broken bone contributes to the separation of the broken parts.
Source: From Loredo, R., Sorge, D., Garcia, G., 2005. Radiographic evaluation of the wrist: a vanishing art. Semin. Roentgenol. 40(3):248–289.

- **Avulsion**: this means that a soft tissue that is joined to a bone, usually a muscle or a ligament, has pulled on its attachment point and broken the bone away. Treatment will depend upon whether there is a need to surgically fix the avulsed fragment (Fig. 3.7). You would discuss the Bennett's fracture in the diagram with orthopaedics.
- **Instability**: some fractures, such as the Smith's (Fig. 3.8), cannot be managed without surgical fixation

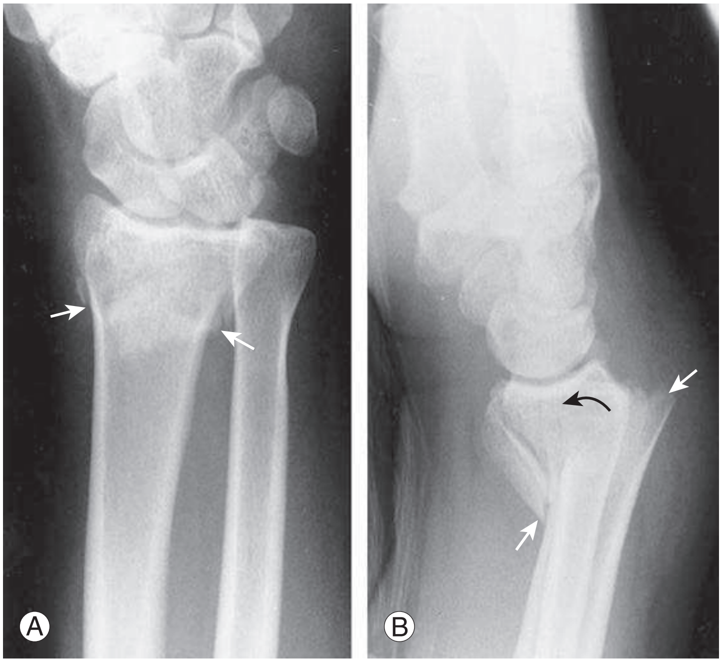

Fig 3.8 Smith's fracture, an unstable injury which requires surgery. (A) Anteroposterior and (B) lateral views of wrist.
Source: From Mettler, F., 2005. Essentials of Radiology, second ed. Saunders.

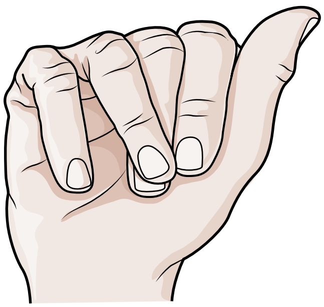

Fig 3.9 Rotational deformity with scissoring.

because there is a displacement of the bone which will not remain in a normal position by any other means.

- **Deformity**: this is a feature of fractures which does not always require active intervention, either because the position of the bone will correct itself during healing, or because the change in position will cause no long-term problems. In certain cases, however, such as a rotational deformity of the fingers, the patient will not recover a normal position without treatment, and will go on to have considerable difficulties (Fig. 3.9).
- **Open**: when an underlying broken bone has created a wound, forcing its way through the skin, there is a risk of infection to the bone in addition to the other problems of fracture management (Fig. 3.10). The patient may require a formal cleaning of the wound in theatre.

Fig 3.10 An open nail bed fracture.
Source: From Browner, B., Fuller, R., 2012. Musculoskeletal Emergencies. Saunders.

These are just a few examples, not exhaustive, of the factors that may influence your approach to an X-ray finding. There will be more information on fractures throughout the book. Ask yourself in every case, looking at the image and considering the clinical appearance and the patient's personal circumstances, whether you can see anything that suggests that healing will be difficult or incomplete. Become familiar with the anatomy of the bones and with how they normally look on an X-ray. Learn how the soft tissues, which do not figure in any detail in the X-ray, may complicate the picture that you can see on the screen. The soft tissues are often decisive for healing and for the prospect of healing but their effects are easy to overlook because they are not seen. Decision-making can be difficult in many cases and you should consult a senior or specialist opinion when you are in doubt.

Part 2

Limb injuries

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Chapter 4

Basics of musculoskeletal injury

CONTENTS

INTRODUCTION

Patients with minor injuries present either with problems to the limbs or to the midline of the body from head to pelvis. Your approach to these alternatives is significantly different and we will discuss them separately. Patients may also present with closed or with open injuries, wounds. Once again, there are important differences between these two and we will look at them separately.

The largest number of patients presenting to minor injury units (MIUs) arrive with closed limb injuries. Confident examination, diagnosis and management of these presentations are core skills for the emergency nurse practitioner (ENP). This part of the book will help you to begin: you will continue to develop your skills and your knowledge for as long as you work. Later parts will look at midline injuries and at wounds to both limb and midline. In all parts of the book we will continue to consider the differences between injuries to children, adults and the elderly.

It can be difficult to assess patients with closed limb injuries or with limb pain and no history of injury. There is no direct access to the injured part, either to see or to touch, and the patient's description of the problem may not make it clear to you which of the possible causes applies in this case.

Children can add to your difficulties by being unable or unwilling to tell you what the problem is or what has happened. They are often brought to hospital because they are limping or because they have stopped using an arm and no one in the family has witnessed an incident to explain the problem.

Elderly patients may have memory problems or impaired communication and you may be depending on a witness to a fall or, once again, on a story of altered walking habits or other changes. It can also be difficult with an elderly patient to know what that person's normal capacities are and to judge whether an injury has caused changes. Once again, this will increase your dependence on the impressions of the patient's relatives and carers and on letters of referral.

Musculoskeletal problems show themselves by two signs, pain and reduction, or complete loss, of normal function in the affected part. The musculoskeletal system is concerned with movement and is inherently mechanical in its action and in its faults. Therefore a loss of function tends to be to a localised change in movement (usually a reduction, but sometimes, in the case of ligament tears and dislocations, an abnormal increase called **laxity**). There are usually no signs of illness such as might occur with failure in another body system and the patient will describe his or her injury to you in a similar way regardless of which tissues are damaged ('I fell on it, I heard something crack and now it's stiff, swollen and sore'). Compare that to the clinical situation when a patient presents with a heart attack. There may be a complaint of pain radiating into the left arm, but you are not likely to linger long with the idea that your patient has a bit of a sprain.

A common reason for an injured person to come to hospital is that he or she thinks that the injury is a fracture and we often find that this is not the case. Ankle inversions probably cause more of this kind of concern than any other injury and it is hard to think of a limb injury that causes fewer fractures as a percentage of patients presenting, or one that results in more negative X-rays. However, we often request X-rays to settle the question because the history and the examination are not conclusive.

It often does not matter which of the musculoskeletal tissues are injured and it is common to see the non-specific diagnosis 'soft tissue injury' in the notes (although, in the following pages, you will be encouraged to be more precise). If an injury is not severe and the management is the same regardless of which tissue is damaged there is no incentive to pursue the matter. There are also cases where it is clear which tissue is damaged and little examination is required to reach a diagnosis. This often happens with more severe injuries such as displaced fractures and large dislocations. (There are pitfalls in assuming an 'obvious' diagnosis, especially when you are inexperienced.) There remain, however, patients who present with problems that require a much closer assessment and where an exact diagnosis has a bearing on the way that the injury is managed and on the outcome.

A robust and simple method of examination and diagnosis will be described in this part, together with the rationale for that approach. The aim is to provide the tools for the first assessment of an undiagnosed patient with a limb injury. The suggested methods are straightforward and, once learned, concise. The detail of how to apply these ideas to examinations around the different limb joints is shown in the following chapters.

We will discuss the principles of musculoskeletal examination in the next chapter. Before that we will do some groundwork by looking at essential information about the language of examination, the anatomy of the musculoskeletal system and the management of acute injuries in this chapter.

TERMINOLOGY

The language of anatomy is used when writing patient records and making referrals. Some general terms are defined in this part. Additional new terms are introduced at the relevant parts of the text:

- **Anatomical position.** Carry this image in your head and base your notes upon it (Fig. 4.1). Any health professional who reads them will assume that you have that position in mind when you describe an injury. The anatomical position looks oddly hieratic, but the figure is standing in a conventional, symmetrical, neutral position except for a single detail, which is that the palms of the hands have been turned forwards in the supine position. The hands are in that position so that the radius and ulna are 'uncrossed', with the radius on the outer side of the arm at both elbow and wrist, and the ulna on the inner side. The figure is simply consistent in showing all parts in a neutral position.
- **Right and left.** Always means the patient's right and left, not those of the examiner.
- **Axis and plane** (see Fig. 4.1). An axis is an imagined line (which sometimes corresponds to the line of a real structure) around which movement happens. A plane is a flat surface. The idea of the body divided by imaginary planes is useful for describing the direction and angle of movement. Three basic planes are described, each at right angles to the others. A **sagittal plane** is vertical, passes from front to back and divides the body into left and right parts. A **sagittal axis** is a horizontal line passing from front to back on a sagittal plane. Movement about this axis (eg, abduction and adduction of the hip) happens on a coronal plane. It may help to think of the sagittal axis around which the hip abducts as a bolt through the joint, passing from front to back and allowing free swinging movement from side to side. A **coronal plane** (also called **frontal**) is vertical, passes from side to side and divides the body into front and back parts. A **coronal axis** is a horizontal line passing from side to side on a coronal plane. Movement about this axis (eg, flexion and extension of the hip) happens on a sagittal plane. A **transverse plane** is horizontal and divides the body into upper and lower parts. A **longitudinal axis** is a vertical line about which certain movements (eg, lateral rotation of the shoulder) occur on a transverse plane.
- **Anterior (ventral)** means to the front and **posterior (dorsal)** to the back.
- **Superior** (or **cranial**, 'towards the head') means above and **inferior** (or **caudal**, 'towards the tail') means below.
- **Lateral** means away from and **medial** means closer to an imaginary midline drawn down the body from head to foot. The term 'midline' is used in a different sense here from its opposition to 'limb' in other parts of the text.
- **Proximal** means closer to and **distal** further from the origin of a limb or other structure: the elbow is proximal to the wrist, and the wrist is distal to the elbow, both in relation to the origin of the arm, which is the shoulder.
- **Flexion** is movement at a joint which reduces the angle between bones on a sagittal plane. **Extension** is the opposite movement at the same joint: the elbow flexes to bring the hand nearer to the shoulder and extends to bring the upper arm and forearm into a straight line. The position from which flexion begins varies from joint to joint. The elbow lies in full extension and flexion starts from that position, but the head and neck are usually held in

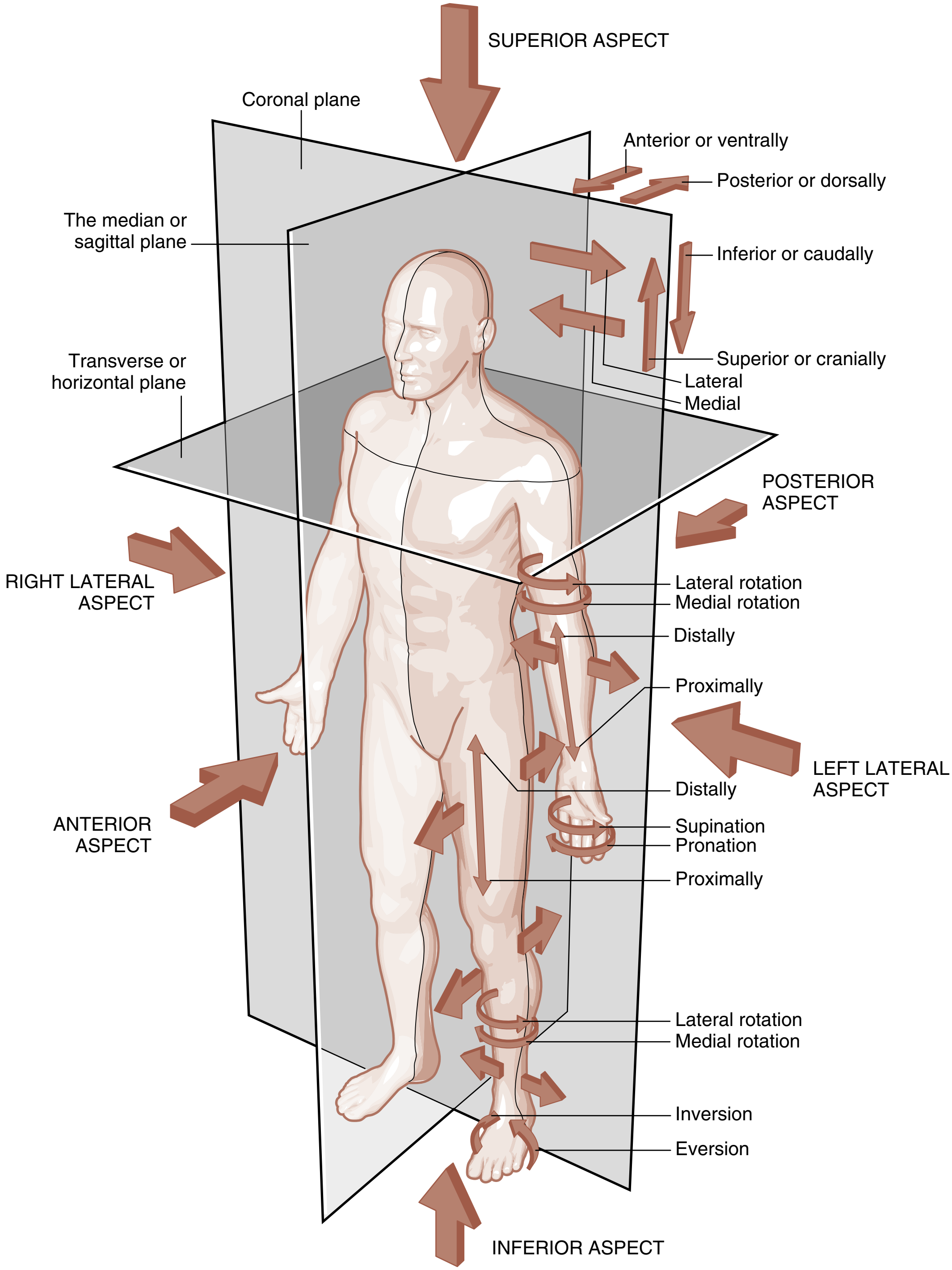

Fig 4.1 Terminology of anatomical position. AD, adduction; AB, abduction; FLEX, flexion; EXT, extension; M and L, medial and lateral rotation; P, pronation; S, supination; I, inversion; E, eversion.
Source: From Standring, S., 2008. Gray's Anatomy, fortieth ed. Churchill Livingstone.

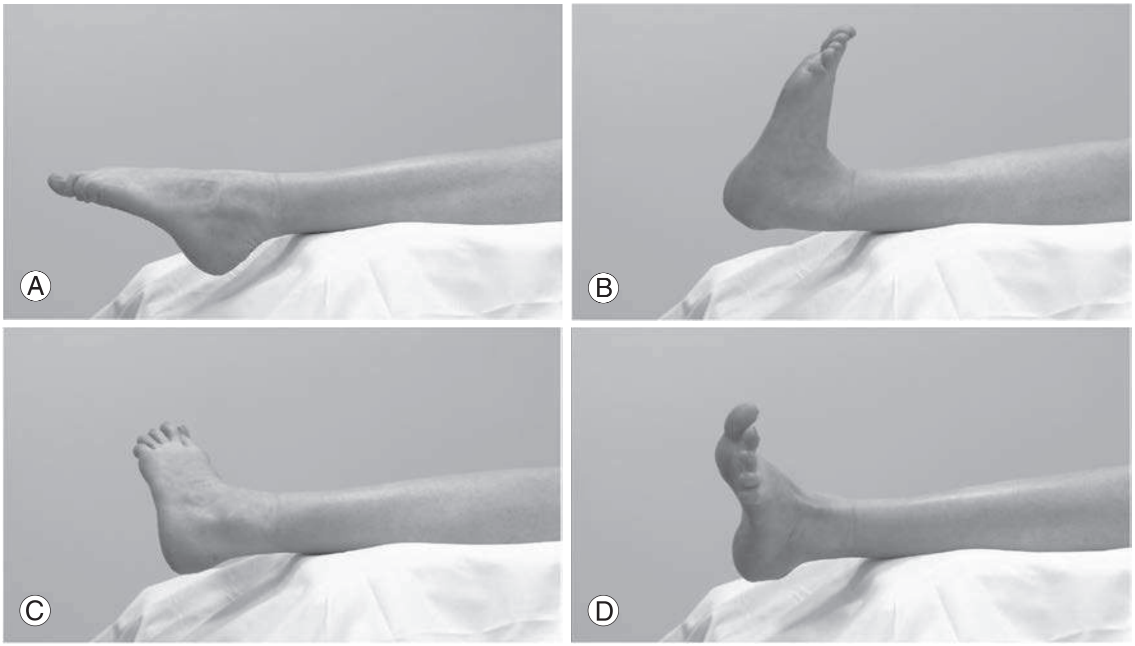

Fig 4.2 Movements at foot and ankle. A, Active plantar flexion; B, active dorsiflexion; C, active inversion; D, active eversion.

a position midway between flexion and extension. Note that flexion occurs in an anterior direction at the elbow and in a posterior direction at the knee, but both movements occur on the same plane. Flexion in the upper part of the body is related to purposeful coordination of hand and eye and always occurs in the anterior direction. The muscles of flexion are stronger than those of extension. Extension is a junior assistant to flexion. In the lower part of the body, the functional emphasis is on weight bearing, and the key relationship is with the pelvis and the spine. The spine is a series of alternating curves that absorb the forces generated by walking. The legs continue that principle and, in comparison with the arms, which they structurally resemble, they are rotated in a posterior direction. This explains why flexion is anterior at the hip but in a posterior direction at the knee.

- Special terms are used for flexion and extension at the ankle (Fig. 4.2). The foot joins the leg like the crosspiece on an upturned letter T. The angle between foot and leg is reduced and increased by movement in either direction, and it has been deemed that this makes a distinction between flexion and extension difficult. Therefore, movement of the foot towards the shin is **dorsiflexion** (see Fig. 4.2B) and pointing the toes down is **plantar flexion** (the sole of the foot is called **plantar** and the surface which we can see when we look down is the **dorsum**).

Fig 4.3 Abduction of the shoulder.

- **Abduction** is movement away from the midline of the body on a coronal plane, for example at the shoulder when the arm is lifted away from the side (Fig. 4.3). In the hand, abduction is movement of the fingers away from the midline of the middle finger. In the foot, the toes abduct from the midline of the second toe. **Adduction** is movement towards the midline, the reverse of

abduction. Certain movements on the coronal plane cross the midline and combine abduction and adduction; consequently, these words are not useful. Movement to the side at the cervical and lumbar spine is **lateral flexion**, or side flexion, to right or left. Side-to-side movement of the hand at the wrist is called **deviation**, and its directions are named for the forearm bone that the hand moves towards, **ulnar** and **radial.** In other words, movement of the hand, at the wrist, towards the little finger is ulnar deviation and towards the thumb is radial deviation. Abduction is a term which causes confusion at the thumb. Movement of the whole thumb away from the hand in a palmar direction is **palmar abduction**, and movement of the whole thumb to the radial side is **radial abduction.** Movements of the thumb at its two internal joints are flexion and extension. These and other movements of the thumb are discussed in Chapter 8.

- **Circumduction** is a fluent sequence of four movements, flexion, abduction, extension and adduction, at one joint, to make a single circular movement. The movement can be clockwise or anticlockwise. Hip, shoulder, wrist and base of thumb are all capable of circumduction.
- **Rotation** is movement of a bone around a longitudinal axis, for example at the neck, shoulder and hip; towards the midline of the body is **medial** or **internal** rotation and away from the midline is **lateral** or **external** rotation. At the neck and waist, where the rotating part is in the midline, rotation cannot be described as medial or lateral, and as with side flexion, it is named right or left.
- **Supine** means facing upwards (or forwards in the anatomical position) and **prone** face down or backwards. **Supination** of the hand is movement to the palm-up position by lateral rotation of the forearm when the elbow is flexed to 90 degrees. **Pronation** of the hand means turning the palm down by medial rotation of the forearm with the elbow flexed to 90 degrees. Note that the hand can also be rotated from the shoulder when the elbow is extended. A patient may try to do this if forearm movement is reduced. It is therefore best to examine forearm movement with the elbow flexed to eliminate the influence of the shoulder. Supination of the foot means raising its medial edge, a movement more commonly called **inversion** (see Fig. 4.2C). Similarly, pronation of the foot, lifting its lateral edge, is usually called **eversion** (see Fig. 4.2D). This is a simplification. Foot and ankle movements are complex, multi-joint combinations.
- **Valgus** and **varus** describe the direction of a body part or a movement in a coronal plane from a given point where that direction changes. The words are often used to describe angulated deformities in bones or around joints. They always refer to the direction of the distal part of the deformity. Valgus means angulation away from the midline of the body (eg, knock knees). Hallux valgus, the condition commonly known as bunion, refers to the abnormal lateral direction of the big toe (hallux) from the metatarsal phalangeal joint. If someone's knee is struck on the lateral side so that the ligament on the medial side is stretched, this can be described as a valgus stress to the knee. Varus means an angulation towards the midline (eg, bow legs).

THE MUSCULOSKELETAL SYSTEM AND HEALING

This section introduces musculoskeletal anatomy and contains general information on the healing process. This is followed by a more detailed survey of the anatomy of the different musculoskeletal tissues, how they are injured and how to treat them. Particular injuries are described at the appropriate places in the following chapters on the individual joints.

The Musculoskeletal System

The musculoskeletal system is a frame made of segments of hard connective tissue, bone, held together by various softer connective tissues (skeletal muscle, tendon, cartilage, ligament, synovium, bursa and fascia). Connective tissue is characterised by large amounts of extracellular material, mainly the proteins collagen and elastin, which give it strength and resilience. The frame is moved, around its joints, by the contractile skeletal muscles. The functions of the musculoskeletal system are protection of the organs, movement and stability.

Movement and stability are conflicting priorities: stability is easily attained by lying down and doing nothing. In our waking lives we stand erect, we move around, we reach out with our hands, we give up absolute stability so that we can interact with the world around us. Stability becomes relative and dynamic, subordinate to movement but an indispensable partner with it. Our stability may be challenged by the forces which we meet in the world beyond our bodies. Internally, the forces generated by our own muscles and the alterations caused by our slightest movements require an endless stream of stabilising adjustments.

The structure of different parts of the musculoskeletal system and the problems to which it is prone reflect, in part, this trade-off between movement and stability. The shoulder is highly mobile but prone to dislocation. The knee will accept heavy loads but can be injured by slight abnormal movements.

Severity of injury (Box 4.1)

A useful simplification of your task in assessing closed limb injuries is to say that you are looking among the day's presentations for fractures and grade 3 tears of the muscles and ligaments. This *is* a simplification: it is valid and useful to the extent that these are the injuries that tend to trigger most of your referrals to emergency orthopaedic services and follow-up clinics. Referrals to surgeons always imply the question, does the patient needs some kind of surgical repair in order to become pain-free and to regain full function? If the patient will not recover without that kind of help then it is an important part of your job to understand that at once so that a critical delay does not occur.

What is a grade 3 soft tissue injury? Soft tissue injuries are classified in different ways and certain aspects of description are peculiar to individual tissues but it is acceptable to label the tears to ligament or muscle which make up the bulk of acute presentations as **grade 1**, **2** or **3**, meaning minor, moderate and severe, respectively (Box 4.2).

In the MIU you make these distinctions by assessing the severity of the mechanism of injury, the appearance of the injury, and, especially, the pain and disability it has caused. Use this grading system for three purposes: to clarify your thinking about the severity of an injury by assessing it in line with simple criteria, pain and disability; to document the injury in a way that is common to other professionals; and to support your chosen management plan.

The two variables, pain and disability, give you a tool which links the size of a tear to an appropriate plan of management. Disability is assessed differently in muscles and ligaments:

- A muscle with a large, but not complete, tear may retain a full range of **active** movement (meaning, movement carried out by the patient with no help or resistance from you). The extent of the injury will only be exposed when you offer **resistance** to the movement. If the tear is large the muscle will be **weak.** A complete, grade 3 tear will eliminate active and resisted movement.
- A ligament is a strap which fastens bones together at joints and both limits and permits the range of movement which that joint possesses. A large tear to a ligament causes abnormal mobility at the site of the injured ligament, a loss of stability which we call laxity.

A grade 1 soft tissue injury will typically damage only a small number of fibres, up to 5%, of the muscle or ligament (although this figure is meaningless in your MIU because you cannot see the torn fibres unless there is a wound over the site). In terms of pain and disability it will cause pain when the part is used or stressed. There may be some visible swelling and bruising but the patient will not be disabled: muscles will not be weak, ligaments will be firm and recovery will be uncomplicated, with a marked improvement in 1 to 2 weeks. Severe signs such as deformity, heavy bruising and inability to walk will be absent. You will discharge the patient with clear advice on the care of the injury and advice to seek further help if it is not improving.

A grade 2 injury is caused by a more severe mechanism than a grade 1 and there is a larger number of damaged fibres. Pain is present once again but the new feature is disability, with weakness in an injured muscle or laxity in a ligament. Other features such as inability to walk and severe swelling and bruising may add to the impression of a significant injury. There is not a complete division of the whole structure: if you are in doubt about this, treat the patient as having a grade 3 injury. This injury will take weeks or months to heal, and will be prone to the complications of soft tissue healing which are discussed later in this chapter. Begin the patient's treatment at once and make a referral to a physiotherapist.

A grade 3 injury is a complete division of a muscle or a ligament. The most notable clinical finding is complete loss of function, weakness or laxity, in the injured part. Pain may or may not be present, depending on other factors such as inflammation or haematoma. It does not, however, hurt to test the torn tissue, simply because you cannot stress a divided structure. Therefore disability without pain

Box 4.1 **The rule of threes for injuries to limb**

MINOR INJURY: limb, midline, referred
PRESENTATION: sick, injured, overuse injury
PATIENT: child, adult, elderly
PHASE OF INJURY: inflammation, proliferation, maturation
TISSUE: bone, muscle, ligament
EXAMINE: look, feel move
MOVEMENT: active, passive, resisted
FINDING: diagnosis, differential diagnosis, management pathway
COMPLICATING FACTORS: nerve root pain, referred pain, the capsular pattern
SEVERITY: grades 1, 2 and 3
MANAGEMENT: discharge, rehabilitation, surgical referral

Box 4.2 **Degrees of severity of injury**

Degrees of severity – two variables, pain and disability (muscle disability = weakness, ligament disability = laxity)

- Pain with no disability = grade 1 = patient home with advice
- Pain and disability = grade 2 = physiotherapy
- Disability with no pain = grade 3 = orthopaedic review

is characteristic of a grade 3 injury. Other clinical findings, such as deformity, absence of the structure in its normal position or visible and palpable gaps within it, may support your suspicion. The management of grade 3 injuries is either prolonged immobilisation in a position that brings the torn ends of the tissue together, or surgical repair. Some injuries can only be repaired by surgery and others are always treated by immobilisation. For some injuries there may be a choice. Orthopaedic surgeons make these decisions in consultation with the patient and you should refer promptly.

Tissue healing

The various tissues of the musculoskeletal system have different capacities to heal and renew themselves. However, it is possible to describe the process of healing in general terms and to propose some basic principles for the treatment of injuries.

Scarring

The optimum form of healing is replacement of injured cells with identical new cells, so that the tissue looks and functions exactly as before. Skin has a high, but not absolute, capacity to regenerate itself in this manner, and it tends to heal relatively quickly. Musculoskeletal tissues heal slowly and replace injured cells with an inert, tough, fibrous material which forms a scar at the injury site. Ligaments require more than a year to heal and cartilage may not heal at all.

Scar tissue in a moving part such as muscle or ligament causes problems: the scar cannot reproduce the functions of its host. It is strong but inelastic. It shrinks as it forms, distorting the alignment of the surrounding tissue. It blocks nerve impulses. It may give rise to adhesions and be the site of complications such as chronic inflammation, pain and calcification of muscle or ligament. The host tissue does not recover full function and may be prone to further injury.

Minor muscle tears and sprains are often seen as ‘self-limiting’, not serious, but they will have a better outcome with treatment which minimises the problems caused by the scar.

James Cyriax (Cyriax and Cyriax, 1993) declares that the aim of recovery, when moving parts are injured, is ‘the formation of a strong and mobile scar’. This means that ‘healing must take place in the presence of movement’. However, healing of a soft tissue occurs through several phases, each requiring a different approach. A premature return to exercise can be as damaging as prolonged inaction and a severe sprain may benefit from a period of immobilisation in the first days after injury.

The three stages of healing (Box 4.3)

The healing of soft tissue injuries is normally described in three phases, **inflammation**, **proliferation** and **maturation**, with graduated changes in the treatment of each stage:

- Inflammation is a non-specific, immediate response of the body to ‘insults’ which can include injury and infection. Its chief signs are redness, heat, swelling and pain. When inflammation affects a moving part it impairs function and limits the ability of the tissue to heal ‘in the presence of movement’. Injury damages blood vessels and cells. These release chemicals which cause a momentary vasoconstriction followed by a prolonged vasodilatation at the site of the injury. Blood fluids full of clotting factors and antibodies swell the area, causing the signs of inflammation. These substances form a clot from which the construction of healing tissue will begin. Macrophages begin to remove waste material from the area. The inflammatory phase, in the patient’s experience, is dominated by pain, swelling and disruption of normal routines and sleep. It usually lasts for 2 to 3 days, but can be longer in the case of a large injury at a large joint, or at a site with a poor blood supply. Treatment is aimed at supporting the patient, reducing discomfort and allowing this unpleasant stage of healing to do its work in the shortest time possible. Tissue regeneration is yet to begin. Recommend rest rather than movement.
- The proliferation (or organisation) phase begins as the period of acute inflammation ends. Fibroblasts synthesise collagen, macrophages remove the haematoma and a frail network of new capillaries begins to grow. The new scar is developing. At this stage, a certain amount of movement will improve the organisation of the scar and its ability to cope with the loads that normal use will place on it. However, heavy exertion will damage the delicate new tissues. Getting the exercise programme right is important: refer patients with grade 2 injuries to a physiotherapist.

Box 4.3 **The rule of threes for injuries to limb**

MINOR INJURY: limb, midline, referred
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SEVERITY: grades 1, 2 and 3
MANAGEMENT: discharge, rehabilitation, surgical referral

- The last stage of healing, known as the maturation or remodelling phase, is prolonged, lasting for up to 2 years. The healing tissue combines regeneration and fibrosis with a combination of 'like-for-like' cells and a maturing scar. The scar becomes stronger in response to the stresses placed on it, loses vascularity and shrinks until it is smaller than the tissue it replaces. Excess tissue produced around the wound during the earlier phases is reabsorbed. The patient gradually returns to full activity during this phase.

TREATMENT OF ACUTE INJURY

This section will look at the treatment of acute injuries to the 'soft' musculoskeletal tissues, especially to the muscles and the ligaments. There are other soft tissues, each with their own responses to injury, and they will be discussed below. It is not always necessary to find out which tissues are injured because it does not always affect treatment. There are, however, many situations where you are expected to make a precise diagnosis, grade the severity of the injury and choose a specific treatment.

Holistic care

Assess not only the local physical effects of patients' injuries, but also the effects that they will have on their daily lives. Modify treatment as much as you can to help with any problems. Bring out the necessary information when taking the history. If the injury is to the hand find out if they are right- or left-handed, what they do for a living and any hobbies. If a patient cannot walk, ask about home circumstances: is there someone to help, are there stairs? These questions are more important if the patient is elderly. A minor injury may result in a hospital admission for an elderly person or in a referral to community services to avoid that admission.

Patients may have problems related to their jobs. They may be casual workers, or self-employed, and feel unable to take time off to rest an injury. Advise on the best management of the injury and consider whether there are any workplace safety concerns. Your patient may not be able to follow your best advice. Discuss options. Are light duties available? Can schedules be reorganised? It may help the patient in dealing with the employer to give a copy of the treatment sheet, bearing clear advice to rest. (The patient should not normally go to a general practitioner [GP] for a sickness certificate until after a week's absence from work.) You may also be able to speed recovery by referral to a physiotherapist.

The treatment of sports injuries is now a separate specialty. Young athletes often need advice on safe levels of training and the dangers of recurring injury and overuse. They feel pressure to achieve and they may be impatient of the restrictions caused by injury. They are prone to patterns of injury such as growth plate widening and avulsion fractures which are specific to their stage of development. Do not ignore a complaint because the history is vague. Seek advice when a problem is not settling down in the expected way. A second attendance with the same complaint is an escalation which triggers, at the least, a senior or specialist consultation.

Treatment in the inflammatory stage

The treatment of a fresh soft tissue injury is the management of the inflammatory stage of healing. This is normally a period of 2 or 3 days but may, depending on the severity of the problem, be as little as 1 day or as long as several weeks.

Inflammation represents the body's first response to injury, a preparation for the repair process which begins in the proliferative phase of healing. It incorporates changes in cells with leakage of blood fluids through increasingly permeable capillaries and the delivery of leucocytes to the area. The purpose of these changes is to remove debris and to begin to lay down materials for creating new tissue, either by regeneration of the tissue which has been injured, or by repair with scar material. Inflammation is a part of the process of healing but it requires careful management so that it ends at the right time and is not reignited by overloading of the damaged tissue, an eventuality which can inhibit healing and worsen scarring and other complications.

In the inflammatory stage of healing the injured area swells. This swelling is caused by excess fluid around the injury. The contents of swellings vary and the management and especially the dispersal of the swelling can be more or less difficult depending on several factors. Muscle tears cause a large amount of bleeding because muscle increases its circulation when it is active and that is when it tends to be injured. A ligament injury may not bleed to the same extent but the joint tends to react to injury by overproducing synovial fluid, a phenomenon known as an **effusion**. Inflammation causes migration of fluids from cells and vessels into the extracellular spaces around an injury. This fluid will thicken over subsequent days. It is harder to disperse a collection of blood or pus than a thinner fluid. A superficial haematoma may disperse more quickly than a deep one. The difficulty of dispersing excess fluid in a joint will vary according to a variety of factors: the size of the joint, the amount of liquid, whether it is in the arm or leg, how far along the limb it lies and whether it is synovial fluid or blood.

It is the aim of early management that swelling, regardless of its variations and of the need for inflammation to do its work, is banished as quickly as possible. It is our first objective to stop bleeding from a torn muscle and then, later, to encourage the reabsorption of clots. Swelling restricts the range of movement in joints and the patient cannot be stable or comfortable, especially in the lower limb, until the excess fluid has been dispersed.

The method of doing this is known by the acronym **PRICE**, which means **protection**, **rest**, **ice**, **compression** and **elevation**.

Surprisingly, although some variation on this method of treatment is found everywhere, there is no consensus on whether or how it works and its optimum application. The Chartered Society of Physiotherapy and the Association of Chartered Physiotherapists in Sports and Exercise Medicine have tried to address this by issuing and updating guidelines on the use of PRICE, based on a review of the evidence, for the management of injuries to muscle and ligament in the first days after injury. This section is largely based upon that work.

Protection

'Protection' incorporates three distinct concerns:

- The space inside a joint varies through its range of movement and tends to be smaller at the beginning and end and larger somewhere in the middle of the movement (this varies from joint to joint). A swollen joint assumes the position which offers the largest space for the excess fluid: the larger the swelling the smaller the patient's range of movement on either side of that preferred position. The patient will find it difficult or impossible to straighten a swollen joint. The weight-bearing leg is normally able to stabilise itself by ligaments at the front of the hip and the back of the knee which 'lock' when the limb is straight. A bent leg cannot lock in this manner and depends awkwardly on its muscles to keep the patient upright. A patient who is limping on a bent leg will tire quickly and will be unsafe on a flight of stairs. Protection therefore incorporates simple physical safety. Walking aids have a particular role in this context.
- Fresh bleeding and a lack of oxygen to the cells of the injured tissues mean that a torn muscle or ligament should rest until bleeding stops and swelling begins to diminish. The patient should particularly avoid the movement which caused the injury and also avoid loading the affected area in general until the early phase of the injury has passed. Methods of protection, aiming at limiting the use of the injured area, are many and are adapted to the part of the body affected, the severity of the injury, the lifestyle of the patient and other factors. They may include crutches, plaster casts, strapping, splints and slings.
- The pain from a musculoskeletal injury is almost always increased by movement and many injuries are pain-free when they do not move. Protection, the use of a device to limit activity in the injured tissue, is often the most effective measure for relieving pain.

Minimise any protective intervention as much as possible while still achieving the aim. Swelling is likely to be a feature of the fresh injury, and allow for it in the fitting of any splint or cast.

Excessive immobilisation delays healing and reduces the strength of the regenerated tissue and a physiotherapist should supervise the transition from rest to movement for any patient with a grade 2 injury. Protection also has a role in early mobilisation, in the proliferative phase of healing, by allowing the patient to stress the injured tissue without subjecting it to the full impact of ordinary use.

Rest

Rest incorporates two ideas, the avoidance of the movement which caused the injury and the less specific notion of 'loading'. In the leg loading usually equals weight bearing. Protective devices may be applied which prevent the movement which caused the injury but allow some measure of loading.

There is a conflict between the need for rest and the benefits which healing tissues gain from movement. Overuse of a fresh injury may lead to more severe scarring and poorer muscle regeneration, but immobilisation causes new fibres to be weak and badly organised: recovery is slower and the results are less than optimal. A graduated approach, tailored to the severity of the injury, is required.

Patients are often reluctant to rest. Some people are simply impatient and others have difficult lives. The problem is at its worst when a leg is injured and the patient is asked not to walk.

Nevertheless, rest is the cornerstone of first treatment. Deterioration in the cells and fibres of injured tissues can continue for up to a day after the incident. This can be aggravated by use of the injured part. Swelling will worsen, pain will increase, mobility will decline and the second stage of healing will be prejudiced.

The patient is usually advised to rest for 2 days. If the injury is severe the period of rest may be longer and the need for a physiotherapist to supervise the process is greater.

Athletes often have a higher level of knowledge of the management of injuries than the general population and they are strongly motivated to maintain fitness even when injured. You may wish to offer more detailed advice and you may have a lower threshold for making an early referral

to a physiotherapist. The concept of resting the injured part is compatible with exercise to maintain other parts provided that the patient can isolate the different structures while maintaining rest. There are techniques, some discussed later in the chapter, for exercising the structures which are closest to the injury without involving the tissues which are resting.

Ice

Putting ice on an acute injury (sometimes called **cryotherapy**) has multiple benefits. The cold reduces nerve conduction, and this is the probable reason why it relieves pain after a brief period when it may feel uncomfortable. The metabolism of oxygen is slowed down at the injury site. This reduces the rate of cell death caused by lack of oxygen, with a beneficial knock-on reduction in the inflammatory process. The ice pack causes local vasoconstriction, which helps to stop bleeding. Ice is often said to reduce swelling, but this is doubtful.

The benefits which ice is shown to confer are most significant in the first hours after injury. Therefore you should not only advise the patient on the use of ice but also apply it in your unit if the injury is fresh.

There is a good deal of discussion among researchers on the ideal temperatures within the injured tissues to achieve analgesia and lowered oxygen metabolism. Related issues are the difficulty of achieving a reduction in deep tissue temperature without injuring the skin and how to assess the penetration of cold in sites of different sizes and with different thickness of insulating fat. Neither you in your unit nor your patient at home will know what temperatures you are achieving when you apply ice. You will follow guidance which is generic and weighted towards the avoidance of harm.

Harm from ice is a real possibility. There is the potential for an ice burn, a frostbite injury, if it is used for too long or without a suitable barrier. Peripheral nerves which lie near the skin can suffer injury from ice. Thin people are more susceptible to the effects of ice than those who have plentiful subcutaneous fat and the recommended times of application should be adjusted accordingly. Certain patients should not use ice. It should not be placed over a cut, to an area of poor circulation or reduced sensation, in the case of increased or reduced sensitivity to cold, and where a skin condition exists. Be wary with patients suffering from diabetes, peripheral vascular disease, peripheral neuropathy, sickle cell anaemia and Raynaud's disease.

Current advice on the use of ice recommends the following measures:

- Apply ice to a fresh injury.
- Crushed ice on top of a layer of wet cloth has the best penetration.
- Apply the ice over the whole area which is injured.
- The bigger the circumference of the part which is injured, and the thicker the layer of subcutaneous fat, the longer it takes for ice to cool the deep tissues. Thirty minutes is the maximum recommended time to leave an ice pack on and this should be reduced where there may be complications. The treatment is normally repeated 2-hourly but a routine of more frequent applications is sometimes valuable to let the skin rewarm while keeping the deep tissues cool. Ice application should always be intermittent rather than continuous to avoid injury to the skin.

Compression

A compression bandage applies circumferential pressure to an area of oedema to disperse the swelling. The optimal pressure to achieve this is not clear and, in any case, is not measureable in the ordinary clinical area. It seems reasonable that it should be high enough to encourage drainage from the limb but not so high that it interferes with arterial perfusion. An array of variables makes it difficult to apply compression in a way that is consistent or measurable:

- You cannot measure the pressure which your bandage is exerting on a limb as you apply it. Your usual precautions are to observe the toes or fingers for impaired circulation and to ask the patient if it feels comfortable. And, of course, the pressures will change as soon as the patient stands up to leave the department.
- The bandage will slip, sag and stretch quite quickly after the patient departs and the pressures you achieved will change.
- The patient will have to reapply the bandage after every elevation of the injury and will be unlikely to achieve exactly the same pressure as you, even allowing that the pressure that you achieved was the most desirable one.
- Compression should be evenly applied across the part which is bandaged and certainly should not be tighter at the proximal end than the distal. This makes it difficult to see a role for Tubigrip, given that it is not graduated and that limbs get bigger as they ascend. There is a case for applying padding at slender parts of the limb to equalise the distribution of pressure.

Compression may be counterproductive when used in combination with elevation. Elevation appears to reduce swelling more effectively when used without compression. In any case, the compression required to send swelling up to the heart from the ankle when the patient is standing must be greater than the pressure required when the leg is elevated, which means that the bandage will be too tight when the patient lifts the leg.

Patients sometimes report that a bandage reduces the pain in an injury and they often say that it makes it feel more secure. The reduction of any anxiety which accompanies an injury is a worthwhile objective which can be difficult to accomplish because patients do not always disclose their fears and because it is hard to predict what will relieve them. A bandage which makes the patient feel better may achieve unscientific but genuine benefits by giving the patient more confidence to pursue rehabilitation. Tubigrip may come into its own here simply because it is easy for the patient to take it off and put it on as required.

Elevation

The rationale for elevation is that swelling is reduced if the patient can reverse the burden of gravity on the venous circulation by raising the injured part above the level of the heart.

There is evidence that this works, but there is also evidence that the swollen part returns to its former size once the limb is lowered. This is sometimes called the 'rebound effect'. The rebound effect may be reduced if the patient lowers the injured part slowly when a period of elevation ends.

Elevation causes no harm and can be pursued even when the patient is wearing a cast. There are no particular recommended limits upon it except that the patient should always be encouraged towards mobilisation as soon as the injury allows.

Other aspects of treatment

Exercise

The prescription of exercise for the patient with an injury of grade 2 or more is a task for the physiotherapist or the orthopaedic doctor. Patients with grade 1 injuries will not usually require further referral. You will discharge them with simple advice on exercise after injury. When the problem is more severe you may have to give advice on the management of the injury until the physiotherapist can see the patient.

This section offers an outline of the use of exercise during the three stages of soft tissue healing to help you to advise patients until they can see a physiotherapist. Advice to the patient should be based on the individual, the injury and other circumstances, and it should be simple and cautious. You should also talk to your local services, orthopaedic and physiotherapy, and tailor your advice so that it is consistent with their practice. Shared advice sheets can also be very helpful.

The purpose of exercise in the treatment of an injury is to maintain those parts which are not affected by the injury, to restore the parts which are damaged and to allow the patient to return to normal function. Exercise is used to improve flexibility, strength and coordination.

There are specialist physiotherapy services for children and you should also seek them out in your area and link your first stages of management to later care. Children heal more quickly than adults and there is a tendency to emphasise early mobilisation to an even greater degree than for adults. Coordinate decisions on matters like splinting and the use of walking aids with your local service.

Rehabilitation of the elderly is, in difficult cases, a team effort, involving not only physiotherapy, but also occupational therapy, social work, community medical and nursing services and the family and other informal care networks which surround the patient. The objectives of care tend to be more varied than for younger patients, with safety and psychological well-being more to the fore. This reflects the impact which a relatively small injury can have on the delicate equilibrium of an old person's independence. However, the central objective of early mobilisation of an injury is still valid. Joint stiffness and muscle wasting are quick to develop and difficult to banish in old age.

Exercise in the inflammatory phase

During the 2 days after injury, the patient will experience pain, swelling and loss of function of the injured part. There may be muscle spasm. The priority of treatment at this stage is rest and protection of the injury and the reduction of swelling. Injury and inflammation reduce the supply of oxygen to the damaged tissue and exercise can cause undernourished cells to die.

The patient should not repeat the movement which caused the injury, especially when a muscle is torn: this could increase bleeding and separate the torn fibres. If the injury is at a joint, early exercise can increase pain and swelling. If pain is too severe for comfortable exercise, or if exercise triggers pain, it should not be attempted.

The muscles around the injured joint are prone to wasting and progressive weakness. **Isometric** (meaning 'same length') exercise, a contraction of the muscle against a source of resistance which prevents actual movement, held for 6 seconds, helps to maintain tone without disturbing the joint. A patient with a knee injury can press the back of knee into a sofa to give the quadriceps muscles an isometric workout. A gentle form of isometric contraction called **muscle setting** (contraction without external resistance) can be used as a first step, with the joint in a comfortable, neutral position: it will increase circulation, delay wasting and reduce spasm. It can also be valuable for injured muscle, provided that the muscle is in a relaxed position. It can reduce shrinkage of the scar. However, it will be counterproductive if the muscle contracts in a stretched position, or too forcefully, and tears the healing fibres.

When muscle is torn, it is difficult to keep mobility in the surrounding joints because the muscle should not be stretched. **Joint play** exercises allow some mobility to be

maintained without stress on the injured tissue. These exercises are a passive exploration of the joint's range of **accessory** movements (movements which the joint allows but which its muscles do not perform, so that exploring them will keep the joint mobile without stretching the injury), by **distraction** (pulling apart the joint surfaces), **compression** of the joint surfaces, **gliding** (moving the joint surfaces across each other) and **rotation**. The patient will find it hard to perform these exercises alone because they involve passive handling of the joints.

The patient should maintain parts not affected by the injury by active movements, taking care not to involve the inflamed area.

Exercise in the proliferative phase

The new tissue which is laid down during the healing phase aligns its fibres in the direction of the stresses which it experiences. In other words, it develops its strength to cope with the tasks which are imposed on it. The forming scar is more elastic and less shrunken if it develops in the presence of movement. Collagenous fibres which are laid down at an immobile injury are badly organised and weak, and the scar is shrivelled. There may also be other complications such as adhesion and contracture.

However, the new tissue is very frail, and violent exercise can damage it, reignite inflammation (sometimes in a chronic cycle) and worsen scarring.

In the proliferative phase, there should be less pain, less swelling and an increased range of movement. If the exercise programme is too heavy, there may be a return of earlier symptoms, and the aim is to avoid this and make improvement at a pace which is comfortable.

There can be some resumption of active and weight-bearing exercise, using aids such as splints, strapping and walking sticks (see below). Isometric exercise, below the intensity which causes pain, can continue.

Specific difficulties can be addressed, joint restriction and shortness of muscle, by combinations of stretching, passive joint play and isometric exercise, depending on the features of the problem.

Exercise in the remodelling phase

As the new collagen strengthens, a graduated programme of exercise should subject it to the types of stress which it will face in normal life. Attention must still be paid to any adverse symptoms. If the new tissue is injured, the risks of regression, chronic inflammation, restricted movement and poor healing are still there.

The difficulties of reintegrating the injured part into the body's overall activity must be addressed. If the injury has involved sensory nerves, especially in ligaments, it may be that there is a loss of **proprioception**. This is the capacity of the brain to locate parts of the body in space without using the eyes. It allows you to touch your nose with a fingertip with your eyes closed. Loss of proprioception damages coordination in that part of the body. There is also some evidence that sensory changes occur at other sites not directly related to the injury. The aim of rehabilitation is to regain full coordination of healthy and injured tissues. The programme will progress from uncomplicated to multi-directional movement, and to movements which challenge the patient's coordination. The intensity and nature of such a programme will depend upon the types of activity that the patient is returning to. The target is to restore full function as the patient knew it before the injury.

Problems such as weakness in the muscles around an injured joint, or restriction in the joints around an injured muscle, together with any other complications such as adhesions must be addressed by the means already described. Splints and other devices may still be required until any imbalance between joint and muscle has been rectified.

Heat

The effect of heat on an injury is to increase the blood flow and stimulate cell activity. Its benefits include a decrease in muscle spasm, a reduction of pain and a spur to the healing process. It may also help to prepare tissues for a session of exercise.

Heat should not be used in the first stage of healing, when the objective is to reduce bleeding, swelling and inflammation.

A simple way to warm injured tissue, and to relax muscle which is in spasm, is to use a hot water bottle. There are various packs and rubefacient rubs which are more or less effective. The patient should avoid painful levels or prolonged use of heat and irritant and allergy-provoking substances. Any person with a tendency to bleed or a restricted circulation, poor sensation or malignancy should avoid the use of heat treatment.

Ultrasound

Ultrasound is a treatment normally used by physiotherapists and has several applications for musculoskeletal injuries. It sends high-frequency sound waves, through the medium of gel on the skin, directly into tissue. Its effects are described as **thermal** and **non-thermal**. The thermal effects are similar to those of other forms of heat therapy. Non-thermal effects improve the healing environment by stimulating tissue renewal and reducing swelling.

Ultrasound is helpful for the reduction of haematoma, swelling, spasm, certain kinds of pain, myositis ossificans, adhesions and contractures.

Walking aids

The walking aids which are commonly available for the otherwise healthy and mobile person with an acute injury are walking sticks, elbow crutches and axilla crutches.

Patients often resist the idea of using a walking aid. For those patients who need one, it is a part of their treatment. Explain that it is not regarded as optional.

It is worth emphasising that the purpose of a walking aid, based on the rationale that healing should occur in the presence of movement, and that healing tissue organises itself to meet the demands that are placed on it, is to return the patient to a normal walking pattern at the earliest possible time. A walking aid combines two virtues: it lets the patient use the damaged part in the correct way, which means that the injured tissue is getting the best preparation for the tasks that will follow healing, and it supports the vulnerable new fibres during the proliferative stage. It is also the case that limping, even for a few days, is tiring, depressing and stressful to otherwise uninjured parts of the body. There can also be a safety issue. A limp may occur because a joint, perhaps the knee or ankle, is too swollen to move through its full range. This prevents the patient from standing on a straight, stable leg. There is a risk of a fall.

There is often reluctance to issue walking aids in emergency departments (EDs), caused, perhaps, by arbitrary local policies, by lack of awareness of the indications for their use or by a lack of the resource. However, it is an interesting experience when you have a patient who is able to walk but who has a limp, to supply a single walking stick and observe the change, both in the patient's gait and in his or her mood.

A patient who needs a walking aid probably also needs review, either by you or the physiotherapist. A physiotherapist may take a patient through a graduated process, from axilla crutches through elbow crutches to walking stick.

The indication for giving a walking stick is that the patient has a limp which is significant for the walking pattern, but not unstable. Two walking sticks can also be given. If one stick is used, the patient should hold it in the hand opposite the injury so that the arm and leg swing in the natural way, left with right and right with left. If walking sticks are not sufficient to stabilise the patient, but he or she can still take some weight on the injured foot, then elbow crutches can be tried for the support of partial weight bearing. They are more convenient than axilla crutches but not quite so stable. Some young, fit patients can manage to use elbow crutches while non-weight bearing, but there is a marked increase in stability when axilla crutches are used. The usual indication for giving axilla crutches is that the patient is completely unable to walk on one foot.

Crutches and sticks should be fitted so that there is slight flexion at the elbow when the hand rests on the grip, but the shoulder should not be pushed up, nor should the patient have a bobbing motion. If the walking aid is too short the patient tends to stoop and his or her body weight will be badly placed for safety and for the effort of moving forwards.

Elderly patients with impaired alertness or musculoskeletal frailty will not cope with crutches. They require strong arms, balance, agility, and judgment in hazardous places such as roads, kitchens and stairs. A Zimmer frame is sometimes useful for the injured elderly, but it requires some ability to bear weight on the injury and is not a substitute for axilla crutches. Treatment may have to be directed primarily to the patient's immobility rather than the injury itself. This may involve crisis community care or hospital admission.

Splints, strapping and slings

Splints, strapping and slings are used to prevent movement around one or more joints. The immobilisation of fractures is discussed below. Some of the devices mentioned here are also used for bone injuries.

Devices used in the ED and the MIU for immobilising injured parts include the wrist brace, the thumb spica, buddy strapping for fingers and toes and the collar and cuff sling for the shoulder: there are a variety of 'moon boot' and 'air cast' devices to support the ankle and foot. Plaster of Paris and other casting materials whose primary purpose is to immobilise fractures are sometimes used for severe soft tissue injuries.

The degree of immobilisation varies depending on what is possible at the particular joint, on the device used and on the intended effect of the treatment. There are different indications for the use of these devices, and some of these will be discussed throughout the book.

Use splints with care. Restriction of movement is never a good option, although it is often necessary. It can lead to complications such as stiffness, contracture, wasting, weakness and adhesion. Certain joints, notably in the hand, can suffer permanent contracture if they are splinted in an 'unsafe' position. Strapping at a fresh injury can restrict circulation if the swelling increases. Always have a clear objective when using a splint, based on accepted principles of treatment and the particular patient's condition. Give advice, preferably in writing, on how it is to be used, any possible complications and an appropriate exercise routine.

- Rest is the foundation of the PRICE programme, and a splint or similar device will certainly rest a joint. However, complete immobilisation is not necessarily the same thing as rest. In the case of a bleeding muscle, a patient may need to rest completely, whereas one with a ligament tear may be advised to perform gentle movement to prevent adhesions. PRICE is usually recommended for 2–3 days only, after which movement is gradually introduced. The advice on the use of the splint should be consistent with the rest of the treatment.

- Random movement of an injured joint may be the main source of a patient's pain. There may be spasm. Support might do more than any other measure to make the patient comfortable. The most painful phase of an injury may only last for a couple of days. Advise the patient to wean off the splint and on to gentle exercise after this time.
- Physiotherapists will sometimes use strapping to stabilise a painful joint so that the patient can begin to exercise it with reduced movement at selected tissues. The ankle can be strapped so that the foot is slightly everted, and this will reduce stress on the lateral ligaments, while still allowing them to have some movement. Such strategies are in keeping with the aims of treatment during the proliferative phase of healing. Sportsmen often use strapping to stabilise an injury or a vulnerable joint while they play.
- In cases where complete examination is deferred to a later day, or where a patient is to be transferred with an unstable injury, a splint may be of value in preventing any worsening of the problem. It is of particular concern that an unstable injury should not impinge upon nerves or blood vessels. The decision to immobilise a joint may have more to do with the severity of the patient's symptoms than the exact type of injury. Guiding factors are the patient's posture (cradling the arm, holding the head to prevent neck movement), the range of movement at the affected part, the ability to use the injured part, the level of pain and signs such as swelling and bruising.

BONE (BOX 4.4)

Types of bone

The bony frame of the body is called the **skeleton**. The skeleton is usually described in two parts which correspond to the division of minor injuries into limb and midline. The skeleton's midline is **axial** and the limbs are **appendicular**. The axial bones are often formed into cage- or box-like structures or bony channels and their main function is to contain, support and protect our organs. The functions of the appendicular skeleton are twofold: the arms deliver our hands to wherever they will be useful and the legs do the same thing for our whole bodies.

Bone is a hard connective tissue, made of collagen and mineral salts, especially calcium. There are two basic bone tissues, **cortical** (also **compact** or **dense**) and **cancellous** (also **spongy** or **trabecular**) (Fig. 4.4). Cortical bone is smooth and dense and forms the outer shaft of the long bones. Cancellous bone is porous and its tiny calcium struts absorb and channel weight like a buttress.

The skeleton begins to emerge in the womb, growing within a frame of **hyaline cartilage** which it eventually replaces. It is not complete until the child has inherited his or her adult form at some time in the second decade of life. You require a broad understanding of the pace, distribution and sequence of the **ossification** ('becoming bone') process to make a plausible diagnosis of a child's musculoskeletal injury.

Bones are classified into various types:

- **Long bones**: with the exception only of the carpal and tarsal bones and the patellae, the limbs are formed of a chain of 'long' bones linked to each other at their ends by synovial joints. The word 'long' refers to the shape and structure of these bones rather than their absolute length; some are very small. These bones have a cylindrical shaft or **diaphysis**, made of cortical bone on the

Box 4.4 Bone formation

- A hyaline cartilage skeleton is invaded by bone cells in the womb, beginning in the centre of the bone shaft (**diaphysis**) and moving towards the ends of the bones.
- The process of replacing cartilage with bone (**ossification** or **osteogenesis**) will continue while the child is growing. There are gaps at the ends of children's long bones filled with cartilage (**physis**) where growth occurs, and bone also forms in the hyaline cartilage at the joints.

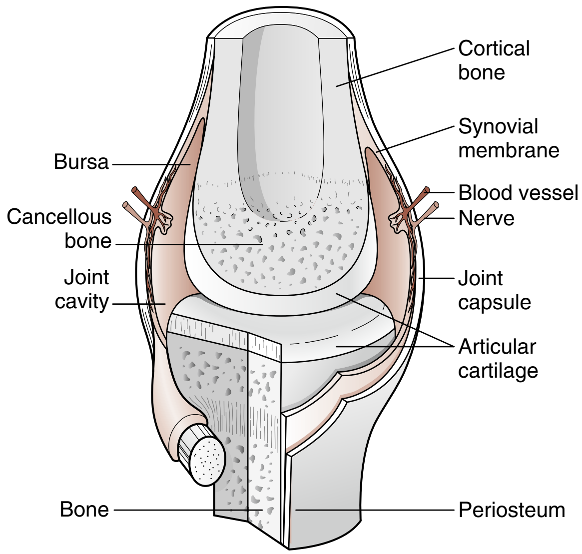


Fig 4.4 The structure of a synovial joint.

outside and spongy bone within, with a hollow core, the medullary cortex, where yellow marrow is produced. The diaphysis is capped at both ends by bone which is shaped to allow it to combine with and move around (to **articulate** with) the next bone along, at a shared structure called a joint. These caps at the ends of the bone are called **epiphyses** (singular, **epiphysis**). Joints all have their own differing ranges of movement and so the ends of the bones also tend to have distinctive formations which allow us to identify each one at a glance. The distal epiphysis of the humerus is the most elaborately moulded of the long bones because the elbow is the only site where one long bone articulates with two. The diaphysis is covered in a membrane called the **periosteum** (Box 4.5), which has a lavish nerve and blood supply and which provides attachment for tendons and ligaments. In children, before the diaphysis reaches the epiphysis, there is another important structure. Long bones tend to have a relatively narrow, cylindrical diaphysis which widens towards the ends, before reaching the epiphysis. This wider area is called the **metaphysis.** Beyond the metaphysis is a narrow, transverse gap in the bone, filled with hyaline cartilage. This gap is the **physis**, or **epiphyseal plate**, also called the **growth plate.** While this gap exists the cartilage within it will generate new bone and the young person will continue to grow. The physis closes when growth is complete and the whole bone fuses and is unified. The articular ends of the epiphyses, the parts which form joints with other bones, are coated in articular or hyaline cartilage.

- **Flat bones** (the scapula and sternum).
- **Short bones** (the carpals and tarsals).
- **Sesamoid bones**: these lie within tendons apparently to increase the mechanical efficiency of the tendon (eg, the patella and pisiform, with others in hand and foot).

Box 4.5 Periosteum

- A double layer of membrane, periosteum, covers the bone except the cartilage-covered joint surfaces.
- Periosteum has a large blood and nerve supply. The outer layer is a tough membrane and the inner layer has bone-generating (osteogenesis) osteoblasts and bone-destroying osteoclast cells. The condition of the periosteum is vital for bone healing.
- Periosteum is joined to bone by Sharpey's fibres. It also provides attachment points for tendons and ligaments.
- A child's periosteum is relatively thick.

- **Irregular bones** (the bones of the pelvis): these bones all have an outer layer of cortical bone, with spongy bone inside. They may be cuboidal, plate-like, oval or irregular.

Figure 4.5 illustrates a growing child's bone.

Bone injury: fracture

A **fracture** is a break in the continuity of a bone (Fig. 4.6). It can be caused by direct violence or by indirect, transmitted force, with injury at a distance from the point of contact. Injury may be transmitted by an **axial** force transmitted straight along the shaft of a long bone (for example, the head of the radius, at the elbow, can be fractured by a fall on the outstretched hand), or by twisting or angulation. Traction (or distraction), a pulling force which separates joint surfaces, can cause avulsion, when a soft tissue such as a tendon or ligament is suddenly stretched and pulls off a piece of the bone to which it is joined. Crush, compression between two hard surfaces, may break bone, often with soft tissue damage and the complications of swelling. Areas of cancellous bone, such as the vertebrae, are vulnerable to crush, but the commonest crush injuries seen in MIUs are to the tips of the fingers.

Stress fracture is caused by the cumulative fatigue of overuse, rather than a single violent event, and **pathological fracture** by disease which weakens bone. These can be more difficult to diagnose because they do not present with a conventional history of an injury.

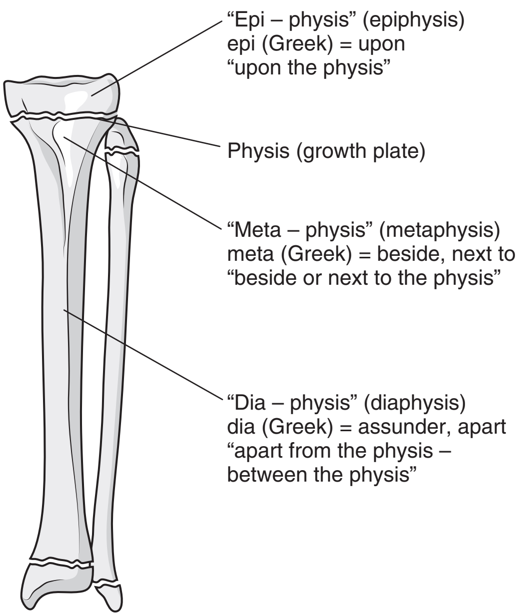


Fig 4.5 A growing child's bone.

Types of fracture

See also Chapter 3.

- Fractures may be open (compound) or closed. An open fracture is caused by a broken end of bone piercing the skin and creating a wound which allows access to contamination and infection.
- A fracture may be **transverse**, with a break at approximately a right angle across the shaft of a long bone, dividing it into two pieces. This happens after a direct blow or bending force to the shaft. The separated surfaces are horizontal and usually keep good position and unite without shortening. However, the broken areas are small and poised one on top of the other, like two pencils balanced end on end. They need support until healing is well advanced.
- An **oblique** fracture is one where the bone is broken diagonally along its shaft. This is caused by a blow to the site or indirect force. A twisting force may cause an obliquely angled **spiral** fracture. The broken areas are larger than is the case with a transverse fracture. This makes union easier, but the angle of the broken surfaces and the action of the muscles attached to the bone may encourage slippage, rotation, angulation and shortening. The bone is sharply pointed and wounding of soft tissue, nerve and blood vessel is a hazard.
- Fractures where the bone is broken into more than two parts are called comminuted. They are usually caused by direct force, sometimes by crush. There are various classifications of comminuted fractures depending on the site of injury, the number of fragments and their potential for union. They tend to be unstable and difficult to treat. The violence of the injury is usually severe and soft tissue damage and impaired blood supply, at least to some of the fragments, are common.
- **Impacted** fractures are those in which the broken ends of bone are driven together by a force along the axis of the bone. Think of snapping a pencil and then driving the ragged ends together. Shortening and displacement coexist with an unreliable stabilising of the broken ends. Sometimes the position will obstruct normal function. A fracture in which an entire segment of bone is punched out and driven in the direction of the impact is called **depressed.** This type of injury occurs in the skull and is also common at the head of the radius.

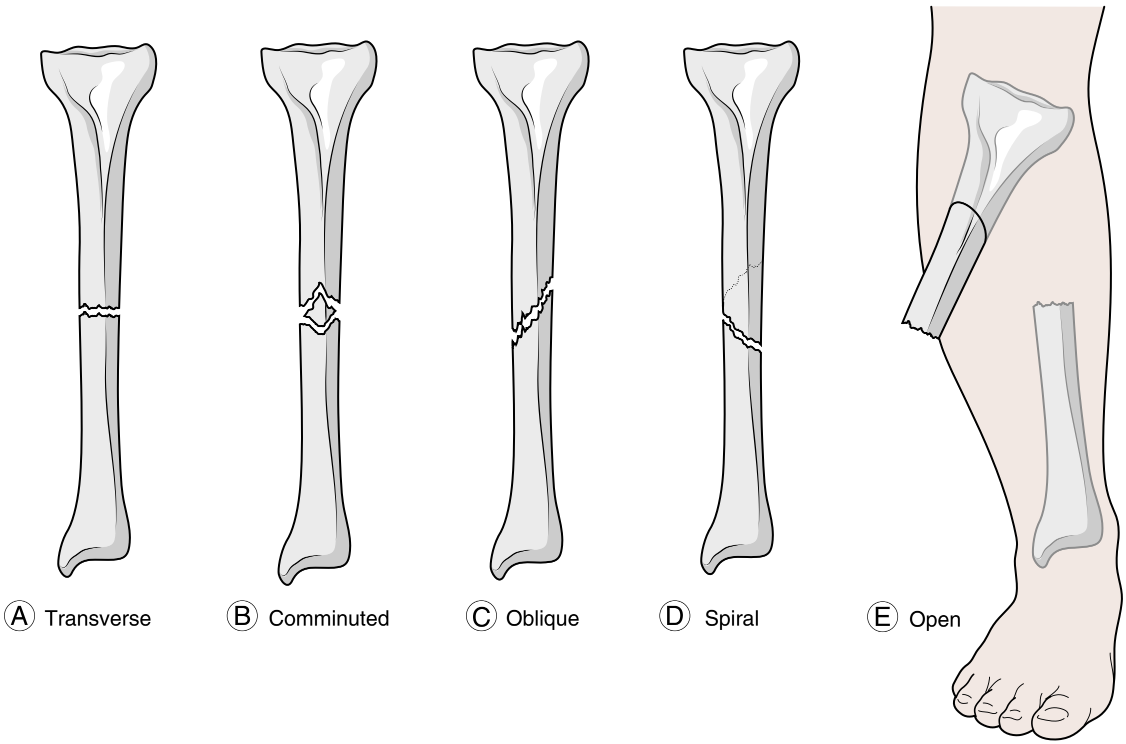


Fig 4.6 Types of fracture.

- Avulsion fractures occur when a soft tissue, commonly muscle or ligament, pulls violently on its bony insertion point and breaks it off. An avulsion, unlike a fracture through the shaft of a bone, will only be tender on the aspect of the bone where the injury has occurred. Such fractures tend to have typical patterns and sites (for example, the base of the fifth metatarsal of the foot) and familiarity with these will help you to make the diagnosis.
- The patterns of avulsion injury are different in young people: there are growth plates not only at the ends of bones but also at muscle attachment points (the bony sites where muscles attach are called **apophyses** [singular **apophysis**]) and these are more prone to avulsion than the fully fused adult insertion. The risk of avulsion is also greater, most notably in the pelvic area, when an adolescent has had a growth spurt. Growth in the bones is not initially matched by lengthening in the muscles: there is a phase where the soft tissues are relatively tight and the stress on the apophysis is greater, especially during dynamic exercise like sprinting. The patient will present with a story that suggests a muscle tear ('I was running after the ball, I felt something "go" in my leg'), but the examination will reveal a tender apophysis rather than a tender muscle belly.
- Adult bone snaps cleanly when broken: it is hard, sometimes brittle, and fractures are all-or-nothing affairs. Children's bones are relatively soft and springy and they can mimic the partial breaking of sap-filled young branches. **Greenstick** fracture (Box 4.6, Fig. 4.7) occurs when an angulation force is applied to one side of the bone: the bone bends and breaks on the opposite side, but not all the way through. There is a tear of the periosteum on the broken side. The periosteum remains intact on the concave side of the injury. There is a degree of deformity, but, unless it is severe, it is likely to correct itself during healing, a process known as remodelling. A **buckle** or **torus** fracture (torus is an architectural 'collar' which is found on classical pillars and the term evokes the bulge which is seen on the dorsal outline of the bone) is one where axial force has compressed a child's bone (Box 4.7). Torus fractures are most commonly seen in the distal radius after a fall onto the outstretched hand. The force of the injury, a combination of axial compression and angulation, is directed by the hyperextension of the wrist to the dorsal surface of the bone: a bulge is seen on its cortex a few centimetres proximal to the physis on a lateral X-ray of the wrist. The volar surface, cortex and periosteum, should be intact. These injuries usually heal quickly with correction of any deformity. A **bow** fracture (the term 'fracture' is misleading; the injury can be a problem precisely because no fracture has occurred) is found when sufficient force is applied to a child's long bone to bend but not to break it. Healing is not triggered and no remodelling occurs. If the injury is to a forearm bone it can change the relationship between radius

Box 4.6 **Children's bones**

- Young bones are relatively porous and soft, leading to various forms of incomplete fracture.
- The periosteum is thicker and less firmly attached to bone, so that it tends to remain at least partially intact in fracture and helps to keep the bone together. Non-union is relatively rare.

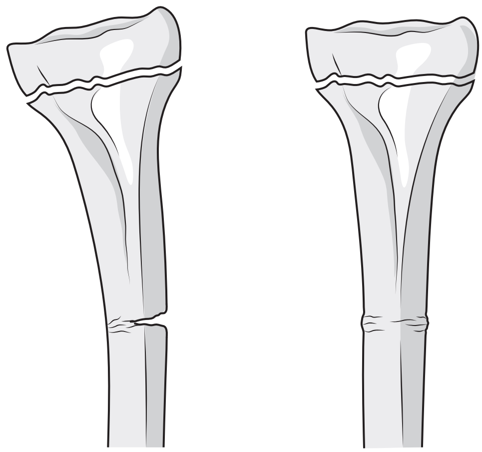


Fig 4.7 Common fractures in children.

Box 4.7 **Terminology**

- Greenstick fracture results from an angulation of the bone, with tension on the convex side, and compression on the concave.
- One side of the cortex is broken, through half the width, and often there is a vertical split at the inner end of the fracture.
- Torus is a Greek architectural word for a round projection. It results from axial compression.
- There is buckling with a slight angulation seen on one cortex of the bone, usually in the metaphysis.
- The commonest site is the distal forearm from a fall on the outstretched hand.

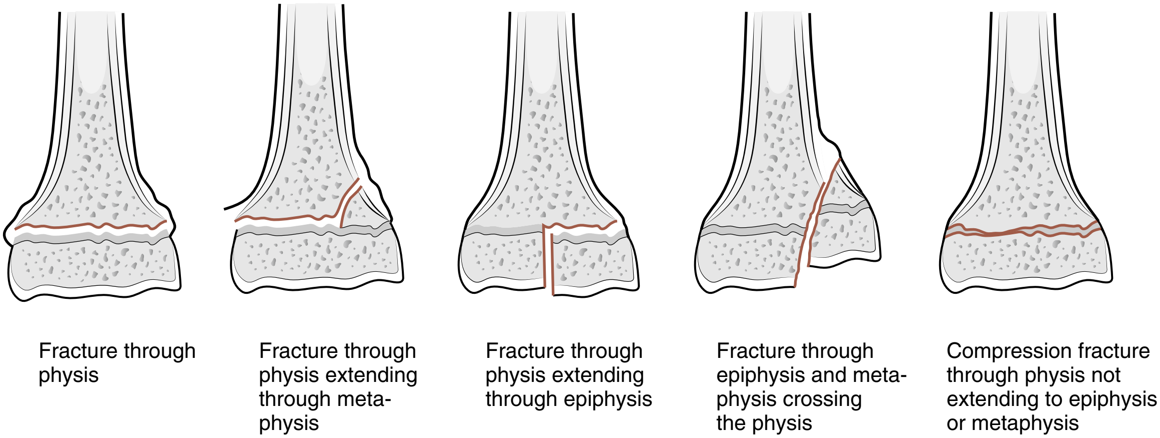


Fig 4.8 Harris–Salter classification of epiphyseal injuries.

> **Box 4.8 Harris–Salter classification**
>
> - Type I – a fracture across the growth plate, with slight displacement, hard to see on X-ray. Good outcome, more or less a bruised physis.
> - Type II – epiphysis displacement with small fracture of the metaphysis (the commonest injury). Good prognosis, sometimes need reduction.
> - Type III – separation of part of the epiphysis. Commonest at ankle. Usually heals well if treated early, unless blood supply interrupted to damaged fragment.
> - Type IV – combined epiphysis and metaphysis fracture. Usually needs open reduction to preserve growth.
> - Type V – impaction of the epiphysis. Leads to deformity and impaired growth. Can be mistaken for HS type I. Occurs with femoral epiphysis slippage and injuries to the epicondyles of elbow.

> **Box 4.9 Fracture healing**
>
> A **fracture** is a break in a bone. The healing process for a fracture occurs in four stages:
>
> 1. **Reactive phase:** haematoma with cell death and inflammation. Fibroblasts begin granulation.
> 2. **Reparative** phase: The periosteum generates cartilage and osteoblasts which lay down woven bone. This **soft (fibrocartilage) callus** is a mixture of cartilage and new bone, and it splints the break.
> 3. **Hard (bony) callus,** a precursor to spongy bone, hardens to renew the internal, and finally the external, shell of the bone.
> 4. **Remodelling:** compact bone is renewed, excess material is absorbed and the bone returns to its previous shape and strength.

and ulna and impair pronation and supination. A bow fracture may need to be manipulated. Fractures to the child's growth plate, sometimes involving the near joint, may arrest the growth of the bone and need expert assessment and, in a few cases, surgical reduction. The **Harris–Salter** classification of growth plate injuries is widely used (Fig. 4.8 and Box 4.8). It is a quick guide to severity, treatment and likely outcome of the various types of injury.

Bone healing (Box 4.9)

Broken bone is the only tissue in the body which can renew itself completely and heal without fibrous scarring.

A haematoma, a blood clot, forms at the site of the fracture. The ends of the broken bone suffer a small amount of necrosis. Inflammation occurs. New blood vessels, fibrous material, collagen and mineral salts appear in and replace the haematoma. A **soft callus** forms, joining the injured ends, with **osteoblasts** (bone-producing cells) and **osteoclasts** (absorbing and removing dead and unwanted bone). The new bone material is spongy rather than cortical and mixed with cartilage.

Callus appears in response to movement at the broken bone ends, to stabilise them and to provide an environment for healing. It is not found where bone is immobilised by surgical pins. It sometimes does not appear at impacted injuries: these heal in a different manner. If the bone ends are well opposed, the bridging process called **union** takes place. Union is a temporary state on the way

to healing. The broken ends of the bone are joined but not strong enough for normal use. This part of the healing process takes 3 to 4 weeks.

Non-union may happen if the broken ends are separated by displacement or because muscle or other soft tissue is caught between the broken ends, if the ends are excessively mobile or if they have a poor blood supply. Comminuted injuries are particularly prone to problems with blood supply. The failure to unite can result in a **fibrous union**, a grossly distorted union, a complete separation of the bone ends or a false joint called a **pseudoarthrosis**. **Mal-union** means that a fracture unites in the wrong position. The significance of mal-union depends upon the site and extent of the deformity but difficult cases require surgery.

From union, the fracture progresses, over a period of months, to **consolidation**. A **hard** ('bony') **callus** of woven bone replaces the soft callus. The injured ends fuse and become stable and strong enough to withstand normal use.

Over a much longer period, up to 2 years, remodelling takes place. The bone is restructured in response to the loads which are placed on it. Excess materials left over from healing are absorbed, and cortical bone reforms along the shaft. The bone slowly assumes its former shape.

All stages of bone healing happen more quickly in children. Remodelling is a more active and perfected process which can even adjust some degree of angulation in a preadolescent. Rotational deformities need active correction at any age.

Treatment of bone injury

Certain fractures, such as undisplaced injuries to small toes, are usually left to heal without special management. The diagnosis is usually clinical as X-ray is not indicated for injuries where the finding will not change the management. Take care to examine such injuries carefully before making any decisions. You may find that you have dismissed someone with an untreated, dislocated toe.

Fractures are the business of orthopaedic surgeons and your care of any patient with a broken bone will follow the policies of your local specialists. The computerisation of X-rays and rising patient numbers in EDs have changed the interactions of orthopaedic surgeons and patients with fractures. More patients with uncomplicated fractures are discharged with advice and no follow-up. Patients who are not thought to be in need of surgery are referred to 'virtual' orthopaedic clinics. This means that the patient's notes and images are reviewed at a routine meeting by the surgeons, without the patient. The patient is then contacted at home by telephone. A face-to-face consultation is not inevitable unless the surgeon sees a risk which was overlooked in the MIU or the patient develops a new problem with the injury. The surgeon may also decide not to see the patient immediately but to ensure that healing has taken place at a later appointment, perhaps 6 weeks down the line, at a stage when referrals for rehabilitation may be required. For patients who require prompt surgery for a new injury the system is unchanged: you will pick up the telephone and make a referral from your MIU.

This means that it is now quite possible that you will be the only health professional who sees a given patient with an uncomplicated fracture. Your key responsibility is unchanged, to diagnose the injury correctly and to evaluate its severity. However, the burden is greater if the safety net has a wider mesh.

It is not clear whether virtual clinics have caused changes in the ways that fractures are immobilised, or whether changes in casting have made virtual clinics possible. A patient who is discharged in a plaster of Paris cast is deemed to require a review, usually more than once, simply because of the cast. Virtual clinics cannot reduce actual clinic numbers unless the patient has a splint or a boot which can be managed at home. There is a growing range of splints, casting materials and devices for the immobilisation of fractures. No doubt, if they are more expensive than plaster of Paris, the reduced demand for clinic consultations offsets the increase. This increases the burden on you to know how to fit an increasing number of devices so that they are effective and the patient is safe and comfortable. Ensure that any device is properly fitted and that the patient understands how to use it at home. Consider other aspects of safety and comfort, such as the reduction of swelling, the protection of skin, the need for a walking aid and the relief of pain. If the patient is to be contacted by telephone check that you have the relevant number. If the patient is not being followed up give all advice verbally and in writing and give a contact number in case of problems.

Emergencies

Among patients who present to minor injury settings with a fracture, the emergency which does arise from time to time is loss of the blood and nerve supply distal to a displaced fracture (a dislocation can cause the same problem), most commonly in the wrist or ankle. This threatens the part which is involved and the patient requires reduction of the displacement to restore neurovascular normality. Some injuries have a recognised incidence of specific complications. Fractures of the upper part of the humerus may damage radial or axillary nerves. Supracondylar fracture of humerus at the elbow may compromise nerve and circulation to the forearm and cause ischaemia of the forearm muscles. Colles fracture can compromise of the median nerve to the hand. Where such complications are possible you are obliged to assess the patient for them, and you would be wise to make more specific comments than the usual 'neurovascularly intact' in your notes. If the patient needs transfer to another hospital, call an emergency ambulance: do not begin any procedure which delays transfer. Lie the patient down and stabilise the injury as best you

can, possibly by using a temporary cast, padded splintage, pillows or sandbags. Neurovascular compromise can occur at any time while a patient is with you. It is important, especially with displaced injuries, including dislocations, to review the nerve and blood supply constantly.

Fractures to large bones, especially in the leg, will bleed heavily. Monitor the patient's vital signs and assess the neurovascular situation, fast him or her, give intravenous fluids and pain relief. If your patient has to be transferred, splint the injury as well as you can in as near to an anatomical position as you can without any attempt at manipulation. Pain is severe with such injuries and treatment will not usually be possible until the patient has received pain relief and sedation or has had a regional anaesthetic such as a femoral block. Fat embolism can occur, especially with fractures of the femur, and acute compartment syndrome can be a risk.

A displaced open fracture requires sterile dressing. If bleeding is severe it may also need compression. Assess perfusion and nerve supply beyond the injury, apply as much splintage as the situation allows, with the part in as good a position as you can attain. The patient will require orthopaedic management for cleaning and repair of the injury. Antibiotics will be given. Other measures are as for the care of closed injuries described above.

Routine treatment

The treatment of a fracture depends on many variables: the part of the body which is injured, the age, health and social situation of the patient, the patient's hand dominance, occupation and hobbies, the patient's expectations for activity after recovery, the presence or risk of complications, the risk of non-accidental injury, the pain caused by the injury, whether the injury is open or comminuted, whether it is displaced or unstable, whether the nerve and blood supply are intact and others. Orthopaedics classifies fractures of every type into subgroups in accordance with the prognosis and the level of intervention that they need.

Management tends to fall into two large groups, injuries which are treated conservatively, usually by immobilisation in a cast or a sling (some smaller injuries are managed in the same way as a soft tissue injury), and injuries which require surgery, usually to apply some form of fixation to the broken bone. Displaced injuries, where the bone is deformed, may require manipulation to restore the normal position. This is often done under a regional anaesthetic such as a Bier's block, or with sedation and analgesia in an ED, but it is also sometimes done in theatre. It can be an attempt at a definitive treatment of the injury with the patient managed in a cast or sling thereafter, or it can be a temporary measure to keep the injury safe until surgery can be performed. Reduction can be open or closed. Some displaced injuries are inherently unstable and will not heal in a cast, without surgery, even if they can be manipulated into a normal position.

The decision in an MIU or an ED that a fracture can be managed straightforwardly is often easy to take. The absence of complicating factors which threaten safe healing is reassuring. Some injuries are so badly disrupted that the opposite decision is also easy. However, you will depend on a detailed knowledge of the common patterns of injury which present, and on access to senior and specialist opinions in difficult cases. There is very little difference on an X-ray between the appearance of a Colles fracture and a Smith's fracture, and they are occasionally confused, but the degree of instability is significantly different from the point of view of management. Many of the factors which affect the outcome are not evident on X-ray, the inherent stability of a bone in a given position, the soft tissues which join it and pull the two sides of a fracture apart. Fractures must be assessed in the context of the whole musculoskeletal system.

Certain fractures are difficult to immobilise because of their anatomical position, such as so-called boxer's fractures at the head of the fifth metacarpal of the hand and injuries to the clavicle, proximal humerus and toes. It is often judged unnecessary to immobilise other fractures such as avulsions from the base of the fifth metatarsal of the foot. In these cases treatments are used which make the best of the situation and give the patient as much comfort as possible, such as the use of collar and cuff for the shoulder, Tubigrip and crutches for the foot, buddy strapping, Tubigrip and high sling for the hand, and buddy strapping for the toes. The outcome in these situations is usually accepted if the patient's pain settles and he or she is able to carry on with a normal life. There will usually be a legacy of less than optimum recovery, often a minor deformity. Be alert for any complicating factors such as a tooth wound at the site of a boxer's fracture or a dislocation with a fracture of the proximal humerus.

Certain fractures are difficult to diagnose on X-ray and may have to be treated provisionally as fractures on clinical grounds alone, on indirect evidence of fracture such as raised fat pad on a lateral elbow view, or after assessment by a specialist. Common occasions for these problems are when treating children, when treating injuries to the elbow and knee and, most common of all in the minor clinic, with wrist injuries which produce clinical signs at the scaphoid. Particulars of these injuries are found at the appropriate place.

A reverse problem often arises with the elderly. An old person with arthritis may have severe symptoms after an injury, and an X-ray that shows an appearance of bony disintegration, sometimes combined with dislocation of the joints. It can be difficult to judge whether these appearances are caused by degeneration or a fresh injury. Their clinical features and the patient's situation at home often, in any case, dictate the management of these injuries. You may have to contact primary care services, crisis care providers, or the orthopaedic team.

Immobilisation

For short-term immobilisation, for transfer or until a fracture clinic appointment, of undisplaced fractures in the distal forearm and wrist, it is possible to use ready-made splints of the type which are often used to rest soft tissue injuries. They are adjustable to accommodate swelling, easy and quick to apply and there is no mess. There is a type available with thumb support which can be used for patients who need review of a 'clinical' scaphoid fracture. Whether or not these splints are regarded as acceptable is partly a matter of local policy. You will also base that judgement on the patient's level of pain. A well-padded plaster backslab does give a greater degree of support and a patient will sometimes be glad to accept the inconvenience of a cast for the extra comfort.

Plaster of Paris for orthopaedic use is available in impregnated rolls of bandage and in lengths of bandage known as slab. When it is soaked in water an irreversible chemical reaction, which produces a modest level of heat, occurs, and the plaster and bandage bond to form a hard, brittle shell.

The plaster bandage can be moulded around the limb to form a splint during the first minutes after it is wet. When it dries, further wetting degrades the plaster so that the splint softens and falls apart: the warmer the water that is used to immerse the bandage, the more quickly the plaster will dry.

Plaster is very messy, travelling around the room in its dry dusty form and as quick-drying splashes when wet. It marks clothing and blocks sinks. It contains lime and you should protect your hands from repeated exposure.

Plastering takes time and requires separate facilities if it is to be done routinely. Some plasters require two staff for proper application. This makes it less useful for stand-alone clinics with small numbers of staff.

Plaster of Paris is a rather old-fashioned casting product nowadays, used mainly in EDs for temporary backslabs, and useful because it is cheap. Fracture clinics will usually use fibreglass bandage when a full cast is applied. It is lighter and tougher than plaster. There are other modern casting products available which can be moulded and which will set in the same way as plaster, but which are easier and cleaner to use. A cast which can be removed and reapplied has obvious advantages over plaster.

There are a growing number of splints and boots which can replace casts on the leg. Their advantages are obvious but they are sometimes cumbersome: they can be positively hazardous if they are not fitted properly or if the patient is not wisely matched to the treatment.

SOFT CONNECTIVE TISSUES

The soft connective tissues of the musculoskeletal system are muscles and their tendons, cartilage, ligaments, synovium, bursa, fascia and joints.

Skeletal muscle

Active movement of the skeleton is achieved by coordinated contraction and relaxation of groups of **skeletal muscles**. These movements can be voluntary or reflexive.

A skeletal muscle has an upper **origin**, a central **belly** and a lower **insertion**. Origins and insertions are usually formed by the attachment of tendon to bone (Fig. 4.9). The belly is the **contractile** area. Belly and tendon have different functions but work as one unit. The place where they meet is called the **musculotendinous junction**.

The muscle crosses at least one joint. The **muscle fibres** are **irritable**, which means that they **contract** in response to a stimulus. When the fibres contract, the overall length of the muscle shortens forcefully (individual fibres can shorten by up to half of their length) and movement of the skeleton occurs around the affected joint. The muscle which contracts is the prime mover or **agonist**. Muscles which assist the agonist are **synergists**. Other muscles, **antagonists**, with action opposing that of the contracting muscle (they move the bones at that joint in the opposite direction), cooperate with the contraction by lengthening to allow the movement. They are **extensible** and can relax and stretch. They are also **elastic** and can return to their normal length after stretching.

Muscles work in harmony, not only as movers of the joints but also as stabilisers, both to prevent and to control movement. In this, they form a partnership with the ligaments, the muscle action being termed contractile, **active** or **dynamic** and the ligament action being termed **inert** or **passive**. This distinction is basic to clinical examination of the soft tissues. The terms contractile and contract can confuse: they are often used to describe action which does not involve a reduction in the length of the muscle. Contraction which shortens the muscle is called **concentric** (eg, in the biceps when the elbow is flexed). Muscles can contract without changing length: this is isometric contraction (eg, a straight leg raise requires isometric contraction of the quadriceps to keep the knee straight and immobile). Contraction combined with lengthening of the muscle is called **eccentric** (eg, the quadriceps contract while stretching to control knee flexion when you walk downstairs).

Muscles contract most powerfully if the fibres lie parallel to the axis of the muscle, and the fibres of many muscles, such as the biceps, are arranged in this **fusiform** manner. However, it is also true that a muscle increases in strength in direct proportion to the number of fibres it contains. The fusiform arrangement limits the number of fibres in a muscle, and many, such as the rectus femoris of the quadriceps, have a **penniform** arrangement. The fibres lie diagonally to the axis of the muscle, like cars parked diagonally to a pavement, increasing their number without unacceptable bulk. This is a trade-off. The length of each fibre (and, therefore, the length of its contraction) is reduced and the direction of its pull is oblique, which is less effective than the direct pull of the fusiform.

Skeletal muscle has a huge number of capillaries to meet the demands of heavy activity. At rest, these vessels can close down to 5% of maximum capacity. The degree of engorgement of a muscle with blood at a time of injury is important because the extent of bleeding, and subsequent haematoma, is a major factor in healing.

Muscle fibres are long cells made up of **myofibrils**. Myofibrils contain groups of filaments, of different types. The movement of these filaments in and out of a position of overlap with each other gives rise to contraction. The **sarcomeres** are the repeating units of contraction along the myofibril.

Muscle cells are successively wrapped, individually, in small bundles, in single muscles and in groups of muscles, in layers of collagenous membrane called **fascia**. Individual fibres are wrapped in **sarcolemma** and **endomysium**. Bundles of fibres, called **fasciculi**, are wrapped in **perimysium**, and a single muscle is enclosed in **epimysium** (see Fig. 4.9).

Muscle fibres are divided into two types. **Type I**, also called **slow twitch** or **red**, takes its energy **aerobically** from blood-borne oxygen and has high endurance. **Type II** (subdivided further into types IIa and IIb), also known as **fast twitch** or **white**, takes energy **anaerobically** by breaking down muscle glucose. It has less endurance but greater power than type I. Both fibres are found in each muscle. The proportion varies from muscle to muscle and person to person but an equal distribution of the two types is normal. During exercise, these fibres become active in numerical order according to demand. Light activity may only involve type I fibres, with harder work needed to stimulate type II. This has implications for training of muscle and for rehabilitation of injured tissue.

Direct injury to muscle is usually caused by one or both of two forces, impact and stretch. There are occasionally other factors such as the effects of extreme heat or cold. Injury to other structures can cause indirect damage to muscle; for example, if the circulation is impaired, if the muscle's attachment to bone is disrupted or if its nerve is injured. The presence, position, extent and treatment of bleeding is a key factor in the recovery of full function.

Injuries to muscle

Rupture

Overload and **compression** injuries cause **rupture**, which may be partial or complete. A rupture is also called a **strain**. Rupture occurs when muscle fibres are torn.

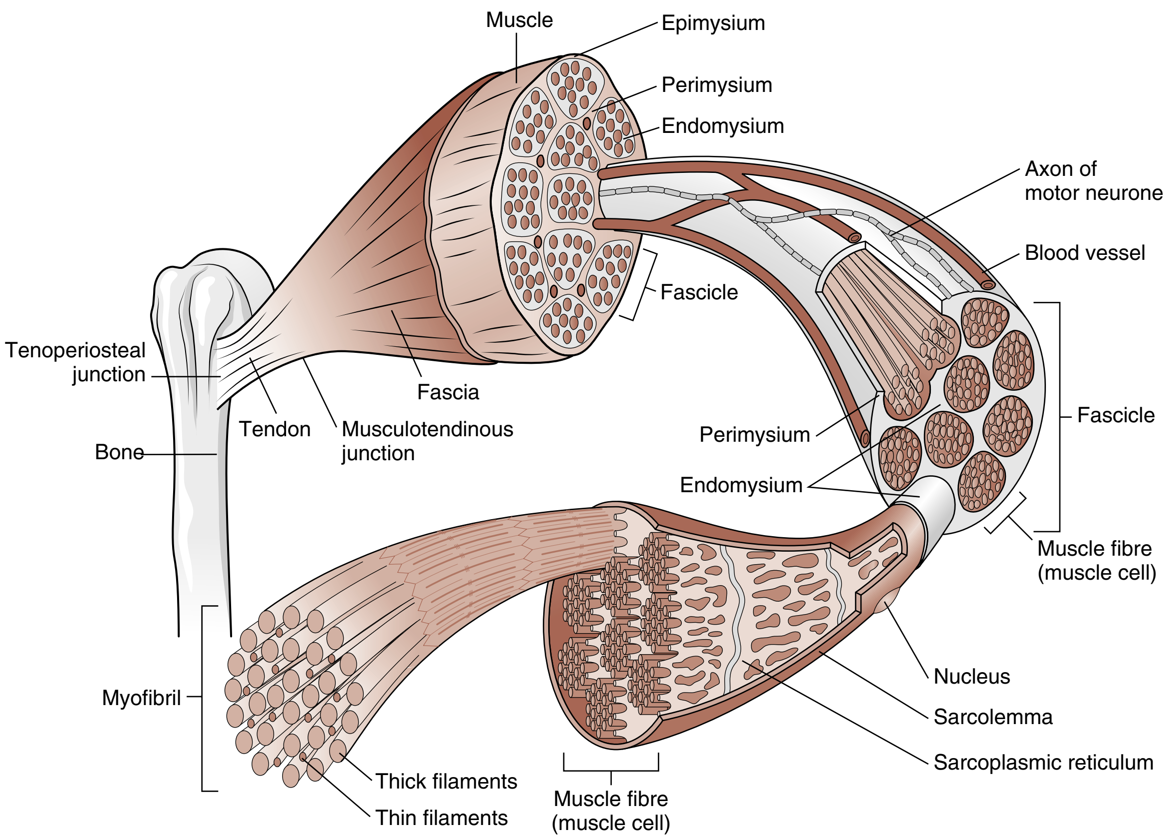


Fig 4.9 Musculotendinous anatomy.

Overload is often the result of the patient's own action, stretching the fibres beyond their limits. Factors such as failure to warm up before activity, previous injury, old scarring in the muscle, tiredness, poor technique or misjudgement of the load may contribute to the injury. Muscles which cross two joints, such as the calf muscles (the gastrocnemius), may suffer contradictory demands during a movement, or demands which exceed their capacities; this type of muscle is particularly prone to rupture.

Compression is the tearing of muscle fibres by a direct blow, which crushes them against bone and causes deep bleeding.

Swelling, induration, bruising and local tenderness may be found with all degrees of rupture, although a very minor tear may only cause localised pain on exertion, with minimal loss of strength and no visible swelling or bruising. This is a grade 1 injury.

Partial rupture may cause pain on active and resisted contraction, and on passive stretching of the muscle (see Chapter 5). Spasm may be present. There is usually some loss of power. This is a grade 2 injury.

A complete rupture may not be painful on examination. Total division of the fibres means that the injury cannot be stressed by contraction or stretching. Absolute loss of function is the key sign, perhaps accompanied by a palpable gap across the muscle or a visible deformity caused by retraction and bunching of part of the belly. The loss of function may be concealed by the action of another muscle which can perform the same active movement. Palpation during movement will show the lack of contraction in the injured muscle, and a resisted test, or other tests specific to that muscle alone, should reveal weakness or incapacity. This is a grade 3 injury.

Bleeding

Muscle injuries cause bleeding, which may be inside a single muscle, **intramuscular**, or between adjacent muscles, **intermuscular**. The amount of bleeding will be determined, in part, by the blood flow to the muscle at the time of injury, which is determined by the level of exertion of that muscle at that moment.

Intramuscular bleeding is contained within the fascia of one muscle. This means that the bleeding may create pressure within the sealed unit of the muscle, which closes the vessels and ends the haemorrhage. In cases where swelling continues, the increase in pressure within the muscle can lead to the complications of **acute compartment syndrome**.

The pressure caused by acute compartment syndrome may cause ischaemic injury to the muscle. It may also compromise the circulation and nerve supply to parts which are distal to the injury, ultimately the hand or foot. Acute compartment syndrome causes severe pain in the muscle, especially when it is passively stretched, and it may swell to the point of rigidity. If it appears that swelling is not resolving quickly after a muscle injury the situation must be monitored carefully. **Pain**, **pallor**, **paralysis**, **pulselessness** and **paraesthesia** are the signs which indicate this potential emergency, but do not wait for a certain diagnosis. Refer the patient on suspicion. Orthopaedic surgeons insert a device called a **compartment monitor** into the affected muscle to measure the rising pressure. If it reaches a dangerous level a surgical procedure called **fasciotomy** is carried out to relieve the pressure.

Intermuscular bleeding is more visible, often with superficial bruising which can be vivid and alarming to the patient, but recovery should be quick with correct treatment.

Blood at the site of injury separates the torn ends of muscle fibre and inhibits healing. This can result in scarring and **myositis ossificans**, where calcification occurs in the fibres of large muscles, most commonly in the thigh, which have not been able to heal because of deep haematoma. These problems cause continuing pain, failure to recover strength, and a tendency to further injury.

Another form of compartment syndrome, where there is painful swelling within the fascia compartment which is *not* caused by bleeding, is called **chronic** (or **exertional**) **compartment syndrome**. This usually affects athletes who have been training the muscles of the lower leg so that they enlarge beyond the limited elasticity of the fascia during exertion. This increases pressure on the muscle, causing pain and a reduction of circulation. Reduced oxygen to the tissues in the compartment leads to oedema, which adds to the problem. Pain is felt during exercise and settles at rest. Chronic compartment syndrome is one of the possible causes of lower leg pain (sometimes called shin splints) in young athletes.

Healing of muscle

Bleeding is the major cause of complication in muscle injury. Haematoma is an important agent in the healing process in all soft tissue injuries, but muscle is enormously vascular. If it is injured during heavy activity it may bleed disproportionately and repeatedly. Normal healing is prevented by a large, deep clot which separates torn fibres and does not disperse, recurrent bleeding and bleeding which increases the pressure inside a muscle compartment. This gives rise to severe scarring and may go on to troublesome complications.

All muscle strains, whatever their severity, separate some contractile fibres, and the torn ends shrink away from each other. The clot occupies the gap.

Muscle healing is a combination of regeneration of new fibre and scarring, with both types of tissue combining in the same fibres. If there is a lot of scar tissue mingled with the contractile fibres, the function of the muscle, which

depends on the coordinated action of many small parts, may be compromised. The scar will be a weak spot, prone to reinjury.

Treatment of muscle injuries

Correct advice about when to rest and when to exercise the muscle is vital for recovery. Without exercise, the muscle will waste and its healing fibres will not organise themselves for a return to function. A premature return to heavy use can lead to further bleeding and excessive scarring.

The core treatment of a new muscle injury is PRICE. Treatment will be dictated by the severity of the tear, the extent of bleeding and whether the haematoma is intramuscular or intermuscular. In mild cases, the patient can be discharged with advice on rest, ice and return to activity (see above). Moderate injuries need on-going treatment, preferably by a physiotherapist, and the patient should be warned against activity while the injury is swollen. In cases where an intramuscular haematoma is worsening or a complete tear is present, the patient should be referred for orthopaedic assessment.

There are specific forms of treatment for injuries at different sites, and these are discussed at the appropriate places.

Tendon

Tendon is a connective tissue, containing collagen and some elastin. Its shape depends upon the size and position of the muscle it serves, but it is often a flattened sheet with an oval cross-section, or round and long like a cable. It connects muscle to bone and relays the power of the muscle contraction so that movement can occur or force be transmitted. Consequently it is very strong. It has only a minimal capacity to stretch, but a great capacity to resist a stretching force.

The tendon joins the muscle at the **musculotendinous junction** and the periosteum of the bone at the **tenoperiosteal junction** (see Fig. 4.9). It also continues into the cortex of the bone as **Sharpey's fibres**.

Some tendons lie, along a part of their length, inside a double-layered **tendon sheath**, which secretes synovial fluid to lubricate the tendon and guides its movement. These are found at points where the tendon is subject to stress as it passes over a joint, through a bony channel or is restrained by a ligamentous or fibrous band.

Injuries to tendon

There are two main classes of injury to tendons (see also Chapter 16 for open injury): division or rupture, and disability caused by overuse injury.

Rupture of tendons

Tendons tear when they are stretched to 5% or more beyond their normal length. They may also be divided by blunt force or a cut. Tendons weakened by chronic inflammatory disease, such as rheumatoid arthritis, may rupture under normal load without an injury. Tendons or parts of tendons with poor blood supply, such as the distal part of the Achilles tendon, may also be prone to rupture. Tendons lose their resilience with age, and a burst of unaccustomed activity by a middle-aged person may lead to injury. An overwhelming external force or a sudden and sustained muscle contraction may cause a tear.

The damage can be partial, with pain but no obvious loss of function, and the sufferer may not realise that the tendon is torn. There is a history of injury, local tenderness and pain on resistance and passive stretching of the tendon. Sometimes a bruise is seen, and a defect may be seen or felt at the site of injury. A failure to treat this injury properly, with the correct balance of rest and graduated exercise, can lead to chronic problems. The healing tendon develops scar tissue, which is repeatedly reinjured by the action of the muscle. Pain becomes established and difficult to treat.

Complete rupture of a tendon, particularly common in older manual workers (at the rotator cuff of the shoulder), and older sportsmen (at the Achilles tendon), announces itself in various ways. There is usually a crack and a sudden pain at the back of the ankle when the Achilles tendon ruptures. Rotator cuff tears are described as causing a brief pain at the time of injury, then a period of relief and then a later onset of more severe pain. The loss of function is marked, with severe compromise to the use of the limb with both injuries. The rupture of the extensor tendon of the distal phalanx of the finger, the **Mallet** finger, is often painless, and the patient is chiefly aware of deformity and loss of function. It is true of all cases of complete rupture that the function of the muscle attached to that tendon will cease completely. There may be a gap felt at the tendon, and there may be bruising and tenderness.

Painful tendons

There are a number of difficulties when assessing and treating a patient suffering from painful tendons with no history of violent injury. The symptoms are frequently caused by subtle factors, often unknown to the patient. There is no clear history of injury, and no immediate guarantee that the problem is not medical. Tendons are exposed to stress at joints, and the symptoms are often felt there. It may be hard to tell whether the problem arises from the joint or the tendon. Some cases are caused by a one-off burst of unusual activity, such as redecorating or moving house, and these usually settle when the cause is removed. More difficult are the cases which are caused by prolonged overuse, at work or following a sport or hobby. Failure to diagnose and treat these patients properly can contribute to prolonged

disability, affecting a key part of the patient's life. Healing can be slow and the problem can recur. Patients who are committed to a sport, or who depend upon an activity for their livelihood, are often reluctant to rest and may not comply well with treatment.

Inflammation is a feature of any injury and is a part of the healing process. It becomes a problem in its own right when it is prolonged. It can contribute to scarring, adhesion and contracture. It may be the chief source of symptoms and cause prolonged and worsening disability.

The signs of inflammation are swelling, redness, local heat, pain, tenderness and disability. When the mobility of a lubricated tendon within its sheath is impaired by inflammation, **crepitus** is often felt at the site.

Overuse injuries are caused by repetitive wear rather than a single violent incident. The injured part is not being used properly but can sustain the accumulation of injury for a time. Damage follows when either the load or the frequency of action (or, in some cases, both) is beyond the endurance of the injured tissue. The patient may be predisposed by physical makeup, and external factors such as bad technique and poor working conditions may add to the problem.

Overuse in the Achilles and the patella tendons has been shown to cause pain accompanied by changes to the tendon, the nerve supply and the circulation. These changes are not accompanied by inflammation. The patient has a **tendinosis** rather than a **tendinitis**. These findings have implications for treatment and rehabilitation and they certainly call into question the value of non-steroidal anti-inflammatory medicines in these cases.

Tendinitis is inflammation of the tendon itself. A small tear in the tendon may cause the problem, creating a permanently painful, chronically inflamed scar which never heals because movement of the tendon provokes it. Tendinitis can occur anywhere in the length of the tendon, and also at the musculotendinous and the tenoperiosteal junctions. Tennis elbow is an example of the latter.

Tenosynovitis is caused by a roughening of the tendon and the inner layer of its synovial sheath; as a result, there is pain and crepitus when the tendon moves in the sheath.

Tenovaginitis is a thickening of the tendon sheath which causes pain on movement of the tendon but does not cause the crepitus which is found in tenosynovitis.

Trigger finger or **thumb**, also called **stenosing tenosynovitis**, causes locking of a finger in flexion. The patient makes an unusual effort, against resistance, to extend the finger. It straightens suddenly, which is called triggering. This happens because the flexor tendon has thickened and may have developed a palpable node. The enlarged tendon can pass through the tendon sheath during flexion because the flexor muscles are relatively stronger than the extensors, but will not return. This problem worsens and can result in a permanent flexion deformity of the finger.

Tendon healing and treatment

Injuries to tendons may be characterised by any of various features which make healing prolonged, difficult or impossible without specialist treatment.

Inflammation, often ascribed to overuse, may become chronic in a tendon and its sheath and not respond to rest. It may also be associated with rupture or calcification of the tendon. Scarring on a tendon may set up a source of long-term pain and inflammation, and it may prevent the movement of the tendon in its sheath. Nodal swelling on a tendon may prevent smooth passage through the sheath, a mechanical problem which will not heal.

Tendons may break (or be cut). They can heal as other soft tissues do, slowly and with scarring, but there is considerable difficulty immobilising them until they heal. Mallet injuries are usually treated conservatively, with prolonged splinting, but success is not guaranteed, and this method is not always suitable for other injuries. Surgical repair is often necessary, but very difficult in places where the tendon lies in a fibro-osseous sheath, and where postoperative scarring may obstruct the tendon's glide. Patients often underestimate tendon tears because the defect causes little discomfort and does not look bruised or swollen. They will occasionally present with a finger in an established boutonnière deformity, which has developed slowly but painlessly to a point where the contractures are too severe for effective treatment.

None of the resources needed to treat the more intractable tendon problems is found in acute emergency centres. The GP may use cortisone injections; the physiotherapist may use massage and other techniques, or the orthopaedic surgeon may operate.

The patient who presents with a mild, acute tendon inflammation caused by a recent bout of unaccustomed activity should be advised to rest. This means avoidance of any movement which causes the pain. A splint or strapping may be used to immobilise the part. The symptoms will usually settle in a week. The patient can then return slowly to normal activity.

Cartilage

Cartilage is a connective tissue. It is strong and resilient. Its chief limitation is that it has no blood supply and it does not heal well.

There are various types, each performing some variation on the role of buffer. They all contain collagen and elastin, in differing proportions according to function.

- **Hyaline cartilage (articular)** is the type which lines the synovial joints (see Fig. 4.4). It prevents friction between the articular surfaces of the bones. It is rich in collagen, which holds water like a sponge, and it obtains nourishment from the

synovial fluid. An increase in pressure inside the joint squeezes water and waste products out of the cartilage, and a decrease allows it to draw water and nutrients in. Inactivity or a reduced range of movement in the joint lessens the ability of the cartilage to nourish itself. Age causes deterioration, and the cartilage becomes brittle and prone to injury.

- The **menisci** (singular, **meniscus**), two crescents of **fibrocartilage** (see Chapter 10) which sit on top of the articular plateau of the tibia, have greater resilience than articular cartilage. They stabilise the knee by increasing the surface areas which articulate with the condyles of the femur, and they absorb pressure and distribute load. It is usually the case that when a patient is diagnosed with 'locking' of the knee, or 'cartilage trouble' that the tissue which is torn is meniscus. Fibrocartilage is also found in the spinal discs.
- **Elastic cartilage** is a specialised tissue found only in the outer ear and the epiglottis.

Injuries to cartilage

The commonest injury to cartilage which is seen in MIUs is a tear to the meniscus, usually on the medial side of the knee. This is discussed in Chapter 10.

Injuries to the main body of the meniscus are painless. It has neither nerves nor blood supply. Any pain which is felt in meniscus, and any potential that it may have for healing, is at the edge of the structure where there is some circulation and innervation. It is, therefore, common that symptoms experienced in the knee after a meniscal tear are indirect: the inflammation and swelling in the joint triggered by the injury, and the obstruction of normal movement, especially extension, caused by a displaced fragment of cartilage. The joint may 'lock' and may become prone to 'giving way'.

In children, instability of the knee together with pain and interruptions to smooth movement may be caused by an abnormal **discoid** meniscus.

Cartilage healing and treatment

Cartilage is variously described by different authors as a substance which does not heal or one which heals extremely slowly. The cause of this inability to recover from injury is the lack of a blood supply.

The menisci have a blood supply to their outer rims, and some healing and regeneration of excised tissue are possible at these parts. In more central areas, the tissue does not heal. A pattern of recurring problems, gradually or suddenly getting worse, is a well-known feature of meniscal injury.

Treatment of a suspected acute meniscus injury in an MIU begins with relief of the immediate symptoms. In the knee, there is often swelling, pain and disability, and these can be dealt with in the ways already described. Crutches may be needed. Early physiotherapy can help with recovery of mobility but cannot cure the underlying problem. This should be addressed according to the severity of the situation. Ultimately, a troublesome meniscus may need surgery and the patient will find his or her way to an orthopaedic clinic. If the patient's symptoms are not severe, and, in particular, if there is no severe problem with 'locking', recommend a return to active movement as things settle down. In many cases, the problem will quieten down and will not merit surgery. The patient may need referral to a surgeon if the problem goes on, if it recurs, or if it worsens. In this case, the patient should go to the GP for referral. In the case where a patient has an acute, disabling locking episode, and the history and examination rule out any other concerns, it is worth trying 'distraction' of the joint, separating its surfaces by traction above and below the knee and taking it through flexion and extension and side to side movement. This may open the joint space enough to release the obstruction, and, at worse, it will do no harm. Few patients with a locked knee are happy to be approached by someone who intends to handle the joint vigorously. Give analgesia, consider the use of Entonox and reassure the patient that stretching the joint in this way usually reduces discomfort. You may be rewarded with a 'click' and an improved range of movement. If there is no sign of improvement return the knee to the patient's chosen position before releasing the traction so that you do not trigger severe pain. A patient will be very glad to have locking released, even as a short-term measure while awaiting orthopaedic review.

Ligament

Ligament is a key element in joint stability. It is a soft connective tissue which fastens bones together at the joints. It contains elastin as well as collagen but resists stretching rather than accommodating it. It is often the tissue which limits the range of a particular movement at a joint. It tends to be taut, pulling the articular surfaces together, at the start and end of the range of movement, and lax in the mid-range, allowing the bones to separate. If there is extra fluid in the joint, perhaps caused by an effusion, the surfaces are pushed apart and movement is restricted at both ends of the range. The extent of this restriction depends on the size of the effusion and the particular joint which is affected.

The placement of ligaments around a joint is determined by the range of movement in that joint but there are certain common patterns. Many joints, often categorised as hinge joints, have a large range of movement in flexion and extension, but very little side to side movement. Such joints will usually have ligaments on the lateral and medial sides

which cross the joint vertically, like a simple strap, and prevent the undesirable movement. These are called **collateral ligaments**. Some collateral ligaments are arranged in two or thee parts which lie diagonal to each other. One part will be tight when another is slack. Ligaments usually cross directly from bone to bone, but their arrangements are sometimes adapted to particular circumstances at a joint. Parts of the collateral ligaments in the fingers are joined to a cartilage flap at each joint which is called the volar plate, and these two structures combine to act like shutters which are pulled against the bone as the finger straightens, preventing hyperextension at these joints (see Chapter 8). The collateral ligament at the outer side of the elbow has another ligament for its distal insertion point rather than bone, for reasons that are discussed in Chapter 7. Many common injuries, particularly in the knee, thumb and fingers, are to collateral ligaments and you will often examine them.

Ligament has a poor blood supply and heals slowly, sometimes with scarring and calcification.

It has sensory nerves and injury is a painful event. Through the nerve supply it also has a role in proprioception at the joint, helping to coordinate its movement. This may mean, for example, that an artificial replacement for a cruciate ligament of the knee will result in a loss of stability even if the joint is no longer lax.

Injuries to ligament

People with ligament injuries are a common sight in every MIU. The endless parade, on every day of the year, of patients of all ages hobbling and hopping through the door with sprained ankles is a defining spectacle of that area.

Familiarity should not breed a casual approach. Ligament injuries heal slowly and are prone to heal badly. In particular, they are prone to the complications of scarring, calcification, adhesions and chronic laxity. For the patient, that may translate as recurring episodes of pain, as chronic stiffness or instability and a tendency to further injury. Injury to the cruciate ligaments of the knee often causes permanent instability and may contribute to later osteoarthritis.

Injury is normally caused by direct or indirect violence to a joint, forcing it beyond its normal range of movement or in an unnatural direction, stretching and tearing the ligament. Tears are usually slight, but on occasion there are large tears and complete ruptures of ligament.

The history of a ligament injury is usually clear. The mechanism described means that there will nearly always be a story of a stress to the injured part, forcing it beyond a normal range of movement (although athletes will not always notice the injury if the blood is up in a game like rugby). The sudden stretch and snap of the tissue can cause a loud ‘crack’ which patients have trouble relating to the tearing of a soft tissue, and they assume that they have broken a bone. Ligaments have a nerve supply, and the pain of injury is severe. Patients often describe a feeling of faintness or nausea. Sometimes there is immediate swelling and bruising; more often it happens later in the day. There will be disability, more visible in injuries to the lower limb where weight bearing is compromised.

The injured ligament will be tender to touch and painful when passively stressed, unless it is completely divided, when laxity will be the main sign. If it is possible that the patient has suffered a severe tear (based on exceptional swelling, pain and disability or laxity of the joint), follow the pathway for a grade 3 injury. Techniques such as examination under local anaesthetic, stress X-ray and magnetic resonance imaging are available to orthopaedic doctors, and the joint may need immobilisation in plaster or even, on some occasions, surgical repair.

Begin your assessment by excluding fracture. Ligaments, by their nature, tend to be much shorter than muscles, and are never far from their bony insertions. It is therefore more common to have to eliminate fracture when assessing a possible ligament injury than when assessing an adult with a muscle injury because tenderness will be at a place where ligament and bone meet. (Cases where muscle does avulse bone can be more troublesome because they tend to pull the broken segment further.) The mechanism of injury which produces a ligament rupture can cause an avulsion at the bony insertion of the ligament. Once fracture is excluded, the degree of damage to the ligaments should be established. Sometimes, if the injury is fresh and painful or if instability is severe, there may be muscle spasm, which prevents a true assessment of mobility at the joint. Gross swelling may also prevent an immediate full examination of the injury. The issue of deferred examination is discussed in Chapter 2.

On occasion it is difficult to decide whether an injury is to muscle or ligament. This is one of the key dilemmas of musculoskeletal examination and it is discussed at length in the next chapter. The techniques for assessing individual structures are covered at the appropriate places for each joint.

Ligament healing and treatment

Soft tissue healing was discussed earlier in this chapter. Ligaments heal slowly, taking more than a year to complete the process. It is common for the patient to experience symptoms for 6 weeks after an ankle sprain. Injured ligaments in the fingers can take months to become painless. Especially in injuries of the lower limb, patients are prone to the complications of adhesions, when the moist, injured tissue bonds to bone, and of contractures and calcification.

The aim of treatment of minor and moderate tears is to steer the difficult middle course between the complications caused by immobility and the complications caused by overuse in order to arrive at a strong, mobile scar of

minimum size, with no long-term damage to the proprioceptive functions of the tissue.

In the inflammatory stage of injury, the swelling and bruising around a torn ligament can be massive (especially at the knee or ankle), and it is vital to rest the injury. However, total immobility may lead to adhesions, and gentle passive movement and massage are among the techniques which a physiotherapist might employ. A prompt referral for severe cases will be helpful. The PRICE regimen described earlier in this chapter is designed to reduce the swelling and allow the healing phase to begin.

Gentle, static muscle exercises involve tightening the muscles around the injury for a few seconds at a time with very little change in the muscle length so that the joint is not disturbed. These will help to delay muscle wasting and maintain circulation. Crutches may be necessary at this stage.

In the proliferative phase, the patient will begin a graduated increase in isometric and active exercise. In the case of a lower limb injury, the patient will begin to walk, possibly with the help of a stick. The aim is to walk normally, without limping but to stop if it is becoming painful. Strapping, which holds the injured ligament in a shortened position to protect it from stress (for example, with the foot in slight eversion for an inversion injury of the ankle), may be applied by a physiotherapist.

The patient will also continue to use ice, compression and elevation to minimise inflammation and swelling.

This is the time when it is most difficult to balance the need of the frail, healing tissue for protection with its need to develop in the presence of movement. Any increase in pain or swelling should warn the patient to ease off.

In the remodelling stage, the patient should gradually increase activity back to normal levels, working to restore normal movement at the joint and good power in the surrounding muscle. This may take several weeks and the pace should not be forced.

Coordination around the injured joint, damaged by loss of proprioception as well as inactivity, may require specific exercises if the injury has been severe or the patient has a high level of physical activity in sport or work. Referral to a physiotherapist may be appropriate. A possible indicator that a patient has proprioception problems is a tendency to re-injury, suggesting a lack of coordination at the joint since the original injury.

Synovium

Synovium is a membrane made of loose connective tissue. It is rich in blood vessels but has a poor supply of nerves. It lines the interior of synovial joints, except the cartilage surfaces (see Fig. 4.4). It also forms the inner layer of bursae and tendon sheaths.

Synovium secretes **synovial fluid** into these spaces to lubricate them. The fluid contains phagocytes to clear debris and fight infection, and it carries nutrients to cartilage.

Injuries to synovium

Synovium is prone to inflammation in the presence of infection, chemical irritation, trauma and certain diseases such as rheumatoid arthritis. This causes increases in the output of synovial fluid, producing an effusion into the joint. This condition is called **synovitis**.

Treatment of synovitis

Treatment of synovitis depends upon the cause. It is an inflammatory condition, and the affected area should be rested at first. Normally, in the case of a small to moderate effusion caused by an injury, the injury is treated on its merits, which will include measures to reduce swelling and to keep an eye on the effusion.

A very large effusion at the knee should be referred to a doctor at once. Apart from the fact that it may indicate a more severe underlying problem, the swelling may require aspiration. In cases where a patient presents with an effusion and no history of trauma, always check the temperature and pulse and consider whether any other signs of infection, such as malaise or raised lymph nodes, are present. Examine the joint fully, pay close attention to redness, heat, tenderness and limited movement. Look at the skin around the swelling for any recent break which may have admitted infection. Consider X-ray of the joint to exclude signs of infection and blood tests to check inflammatory markers. If there is a lingering possibility of joint infection the patient should be managed as having septic arthritis until proven negative. Infection can destroy a joint very quickly, and may be managed by both intravenous antibiotics and a surgical washout of the infection. If there are no signs of infection and the patient is sent home, tell him or her to return at once if the swelling worsens or if any systemic symptoms of infection, fever, joint pains, or general malaise, develop. The only completely reliable way to rule out an infected joint is to aspirate fluid from it and examine it for bacteria. Aspiration is a painful procedure at an inflamed joint and it carries the risk of introducing infection to the joint.

There are occasions when a large swelling in a joint after injury, or in individuals who have clotting disorders, may not be a synovitis – there may be a collection of blood in the joint, a **haemarthrosis**. Elements in an otherwise healthy patient's history of injury which will suggest haemarthrosis include a severe mechanism and signs of a grade 2 or 3 injury, but most particularly the story of a large swelling which came up within a few minutes. A typical history of injury with a synovitis might be of, perhaps, a tackle at football, a very painful knee which becomes less painful

after a few minutes. The patient tries to resume play, to 'run the injury off', but decides that it is too painful. He has not noticed any swelling as yet. He sits on the sidelines until the end of the game. By then he is noticing that the knee is beginning to swell, is getting more painful, and he is more disabled than he was at first. The synovitis has a delayed, reactive aspect while the haemarthrosis is simply the result of an immediate large bleed into the joint.

Bursa

A bursa (plural **bursae**) is a sac lined with synovium and filled with synovial fluid. Bursae tend to be found between two musculoskeletal structures which move upon each other, and they reduce the friction between them. Common sites for bursae include hip, knee, elbow and heel. Tendon sheaths are sometimes described as modified bursae. A great many bursae are common to us all, but it appears that they will also develop in other parts of the body in response to repeated stresses caused by particular activities.

Injuries to bursa

Pressure, friction or direct impact may cause traumatic inflammation of a bursa, with redness, heat and tenderness, and a soft swelling. This problem is called **bursitis**. There may be less to see at the site of a bursitis if the bursa is not superficial. Ischial bursitis, at the rear of the pelvis in the buttock, causes pain, disability and localised tenderness, but no redness or swelling. Infection can also cause a **septic bursitis**. The infection may be bloodborne or enter through a break in the skin. It can also be caused by a previous aspiration of a non-infected bursa.

There are several common sites for this condition. At the front of the patella, **prepatellar** bursitis is also called **housemaid's knee** because the problem affects people whose jobs involve kneeling. Nowadays, roofers and carpet layers are more likely candidates. **Infrapatellar** bursitis occurs at the bursa which lies in front of the patellar ligament, and this is also known as **clergyman's knee. Olecranon** bursitis, also called **student's elbow**, occurs at the point of the elbow and is often caused by leaning on the elbow.

Treatment of bursitis

A non-infected bursitis will usually settle with rest and the use of a non-steroidal anti-inflammatory medicine such as ibuprofen (if the patient can tolerate it). The advice on rest should emphasise the need to avoid pressure, friction or impact to the irritated structure. A doctor may wish to drain a particularly large bursa, but this action has to be weighed against the risk of introducing infection and it is usually considered to be ill-advised.

Follow the same advice as for synovitis in dealing with the question of infection. Occasionally a patient will be troubled by a chronically infected bursa. Orthopaedic surgeons occasionally excise such structures.

Fascia

Fascia is a multi-layered tissue. The **deep layer** is of particular concern in the study of trauma, especially to the forearm or lower leg (see also the anatomy of muscle fibres and compartment syndrome, above).

The deep fascia is a tough, inelastic, collagenous membrane which wraps related groups of muscles into parcels (see Fig. 4.9). It is a continuous tissue and can transmit muscle tension to its distant attachments. It is also possible for movement at those distant structures to stress the fascia at its connection to bone and cause inflammation (**fasciitis**).

Injuries to fascia

The inelastic nature of fascia is one of the main factors in compartment syndrome.

Fasciitis is inflammation at the insertion of fascia into bone. **Plantar fasciitis** is a common cause of heel pain, especially in middle age and later life, and patients often present in minor injury clinics with this complaint. The plantar fascia inserts into the heel on the medial side of the sole, at the **medial tubercle** of the calcaneum, and passes distally to the toes. It helps to support the arch of the foot, and it becomes tighter when the toes are extended. Tension at the insertion of the fascia into bone, with small tears, scarring and inflammation, may cause the irritation. Sometimes a bony spur is present at the painful site, but such spurs are often asymptomatic, and pain may be present without a spur (which means that heel pain of that type is not an indication for X-ray). The patient complains of pain when walking, which has a gradual onset, is worse in the morning and gets easier if the activity continues. It returns whenever walking is resumed after a rest. Tenderness at the medial tubercle of the calcaneum, which is worsened by extending the big toe, is found on examination.

Treatment

Plantar fasciitis is a condition which does not settle easily. The patient should be referred to the GP, who may explore such options as a referral to the chiropodist or podiatrist, steroid injection or referral for ultrasound therapy. Malalignment problems in the lower limb are thought to give rise to a number of painful conditions, and plantar fasciitis is one of these. There is a correlation between the problem and a tight, shortened calf muscle, a situation which causes increased plantar flexion at the ankle and, presumably,

extra stress on the plantar fascia during walking. Splinting of the foot in dorsiflexion at night to stretch the calf is reported as having improved some cases.

Joints

A joint is the place where two bones meet. The body has three types of joint, immoveable (the skull sutures), slightly moveable (the sacroiliac joint) and, the type which this text will focus upon, the mobile, **synovial** joint (Fig. 4.10).

Synovial joints share certain features. A **synovial membrane** forms the inner of two layers of the **joint capsule**. It secretes **synovial fluid**, a lubricant, into the **joint space**. The outer fibrous layer of the joint capsule, flexible but very strong, links the two bones. In certain key places the outer layer is reinforced by **ligaments**, and they will play a decisive role in both permitting and restricting movement at the joint. The **articular surfaces** of the bones are covered with smooth **cartilage** to absorb pressure and reduce friction when the bones move upon each other.

Synovial joints vary in design, each according to its role, to reconcile opposing demands for stability and free movement. Generally, the joints in the arm are mobile to liberate the hand, while the joints in the leg are restricted to support the weight of the body. (There are anomalies: the elbow is a simple hinge, while the knee has a range of rotation not found at the elbow. However, the overall range of movement in the elbow and forearm is greater than that in the knee and lower leg.)

There are six main types of synovial joint (see Fig. 4.10):

- **Ball and socket**: the glenohumeral and hip joints combine a spherical head on a long bone with a socket on a bony girdle on the trunk, the scapula for the arm and the pelvis for the leg; movement can occur in all planes, including rotation about the long axis of the bone. The deep ball and socket of the hip allows a smaller range of movement but more stability than the shallow ball and socket at the shoulder.
- **Condyloid**: the metacarpophalangeal joints of the hand (except the thumb) have an oval joint surface that fits a concave depression. It allows flexion, extension and deviation to both sides, movements which combine as circumduction.
- **Saddle**: the trapezium–metacarpal joint of the thumb is a joint which is even more mobile than the condyloid. One articular surface is concave and convex in different directions, like a saddle, and fits the matching contours of the other surface.
- **Plane**: the intercarpal joints have flat articular surfaces that glide against each other.
- **Pivot**: the proximal radio-ulnar joint pivots as the shaft of one bone (radius) is held parallel to another bone (ulna) by a loop; the first bone can rotate about its own long axis inside the loop. The proximal radius moves in this way to allow pronation and supination of the forearm.
- **Hinge**: the elbow has the rounded end of one bone sitting in a notch on the other, like a hinge, allowing only flexion and extension.

Injuries to joints

It is easy to underestimate joint injuries. Very often, the swelling and pain of a fresh injury make full examination impossible, and a second, later assessment is necessary. In many cases, joints are destabilised by ligament injuries which are not apparent on an ordinary X-ray. Muscle spasm may guard an unstable joint and laxity of the ligaments is not revealed on examination.

Dislocation is an abnormal separation of the joint surfaces. A lesser injury, where the displacement is only partial, is called **subluxation**. Dislocation may be complicated by the presence of a fracture, for which the term **fracture dislocation** is used.

The articular surfaces of the joint are held in position by soft tissues, particularly the capsule and its reinforcing ligaments and the muscles which operate across the joint. Dislocation cannot happen without damage to some of these tissues. The return of stability depends upon their healing.

There can be a tendency to underestimate the extent of the damage caused by dislocations. This may be because dislocation is usually diagnosed on X-ray. The image confirms the separation of the joint, but the bones look undamaged and the damaged tissues are not seen. Dislocations can also cause tangling and trapping of soft tissues in and around the joint, and this can make reduction or recovery difficult.

A dislocation may be a single traumatic event which will not be likely to recur when healing is complete. It may also be that the first injury will not heal well, and there will be a tendency for the problem to recur. This often happens at the shoulder.

The shoulder is a special case in terms of dislocation. The glenoid socket of the scapula, which articulates with the head of the humerus, is very shallow. The joint is largely stabilised by a complex of muscles and ligaments. This allows an exceptional range of movement but leaves the joint vulnerable to dislocation.

It may also be that an individual, usually a growing girl, is predisposed to suffer repeated dislocations of the patellae by peculiarities of anatomy, laxity of ligaments, shortness of muscle or the angle of a bone.

Treatment of joint injuries

Patients who have a dislocation should, if possible, be X-rayed to confirm the diagnosis. You will see injuries which look like dislocations but are not. There are occasions where

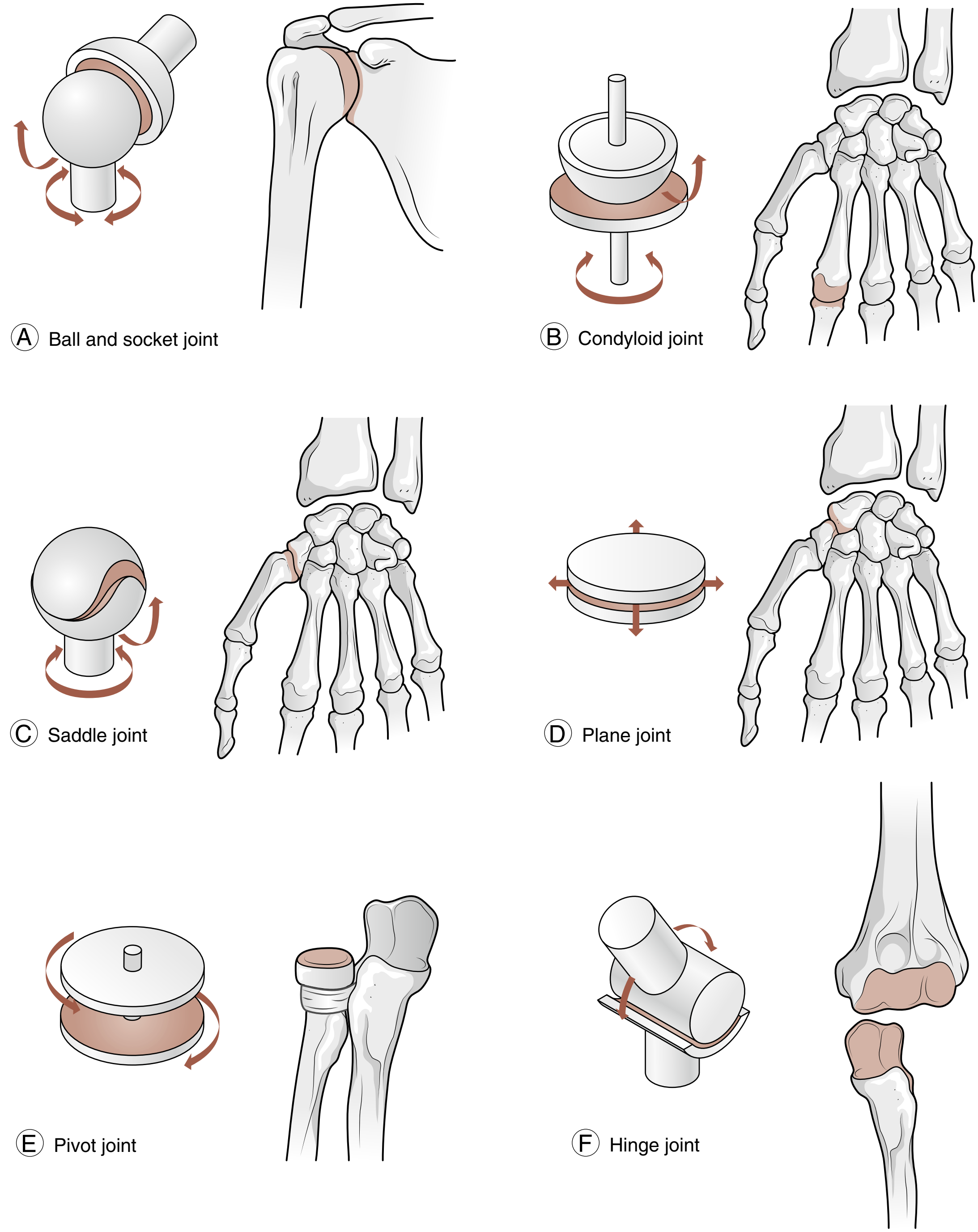


Fig 4.10 Types of synovial joint. A, Ball and socket; B, condyloid; C, saddle; D, plane; E, pivot; F, hinge.

the patient has an urgent neurovascular loss or where X-ray is not available, and treatment is tailored to the situation. Keep a close eye on sensation and circulation: dislocations often pose a significant threat and the patient's condition can change at any time. If you are transferring a patient you may use a sling or splint to maintain the unreduced injury in a stable, comfortable position. If the injury is open, the wound should be cleaned as well as possible and a temporary sterile dressing applied.

The majority of dislocations to fingers and toes can be reduced under local anaesthetic. The injection of a ring block (see Chapter 16) will increase the stress to the neurovascular supply but this is not usually a contraindication. However, if there is other injury, and the digit is poorly perfused, reconsider. A failure to achieve reduction may mean that an open reduction is necessary in theatre.

Dislocations of large joints follow patterns which are typical of each joint. The shoulder has a structural predisposition to dislocation, and it can happen with a minimum of trauma, and will usually recur. Elbow dislocations are usually the result of a violent injury. There will be severe ligament damage on the medial side of the elbow, and there may be fractures which increase the instability of the injury. Hip dislocations in adults are usually of orthopaedic replacement joints. The hip is a very stable joint. Patella dislocations occur easily in some girls and young women, and are related to mechanical factors and growth; they may settle down when growth is complete. Ankle dislocations are usually accompanied by fractures and require surgical fixation. These injuries are discussed at the relevant places in the text.

The reduction of large dislocations is sometimes easy. Some patients can reduce their own shoulders without coming to hospital. There are techniques for gentle reduction of dislocated shoulders, usually requiring analgesia, time and relaxation on the part of the patient. There is no single technique which works in every case. Often, the pain and the resistance to reduction caused by muscle spasm and other factors means that the patient will require a combination of sedation and opiate analgesia before anything can be attempted. Spasm can be very powerful in large, muscular patients. Some elderly patients may have had an undiagnosed dislocation for some time, and it can be difficult to reduce. They also present challenges in terms of anaesthesia. They may compensate for this to some extent by being light and having less muscle bulk.

MIUs are increasingly tackling the reduction of dislocations in cases where complications are not expected and where the patient is willing to attempt the procedure without a general anaesthetic, perhaps using nitrous oxide and analgesia. Reduction techniques will be discussed at the appropriate parts of the text.

Successful reduction of a dislocation is partly a matter of a specific technique which suits the joint which is injured. There are also some general principles which can be mentioned here:

- Resistance to reduction of a joint is often a matter of muscle spasm. Spasm does not surrender to a violent attack. Applying a firm, consistent stretching force to muscle (by techniques like the Milch method for the shoulder) and maintaining it patiently and unfailingly throughout the procedure, will gradually achieve the result. The patient must also be relaxed and comfortable. Many reductions fail, not because the technique is inappropriate, but because the patient is inadequately prepared. It is important not to rush.
- Reductions are passive procedures sometimes carried out on sleepy or unconscious patients. You must be aware of any hazards which the procedure entails (such as the possibility of a spiral fracture of the humerus caused by lateral rotation of the shoulder) because the patient may not be able to give you ordinary feedback on how the procedure feels.
- Dislocations are displaced injuries by definition and the risk of neurovascular compromise is much higher than for most minor injuries. Check the patient's status regularly and after any procedure.
- Once you are happy that a dislocation is reduced, X-ray the joint to confirm this. You may occasionally feel that it is so obvious that the joint is back in place that no X-ray is needed. However, these are unstable injuries, and there may be a second dislocation once the patient has been discharged. There may be some medico-legal value in the evidence of the so-called check X-ray.

In some cases, patients attend with a painful joint and the history suggests a partial dislocation which has corrected itself. In other cases, the patient, a first-aider or some other person may have reduced a complete dislocation at the time of injury, often to a finger on the sports field or after a recurrence of patella or shoulder dislocation. Make a neurovascular assessment. You will usually request an X-ray to exclude fracture and ensure that the joint is in place. Make the injury safe, comfortable and stable, using appropriate splinting for the injured part. Arrange orthopaedic follow-up at a clinic by your agreed local policy.

Chapter 5

Basics of musculoskeletal examination

CONTENTS

BASIC PRINCIPLES OF EXAMINATION

Musculoskeletal injury to the limbs is caused by violence to, or overuse of, the skeleton, the bones and the soft tissues which join and move the bones. Wounds may be present with musculoskeletal injuries, but the methods of examination and diagnosis which are discussed here are for the assessment of closed injuries. In other words, they are an attempt to answer the question which defines clinical activity: how can I find out which of the possible tissues is causing the patient's problem when I cannot see it? A wound is an unpleasant thing but it can solve that problem for you. A surgeon occasionally opens a closed injury if the need is great enough. Imaging is an option: X-rays are relatively accessible but they do not show us the soft tissues in detail and we cannot yet send large numbers of our patients for magnetic resonance imaging (MRI) scans. This means that in a minor injury unit (MIU) the diagnosis of bone injury is finally a matter of requesting an image but the soft tissues, in virtually every case, receive nothing beyond a clinical examination. The examination of bone will be discussed in this chapter but soft tissue assessment, particularly of the muscles and ligaments, will be the main topic. An important aspect of musculoskeletal assessment which goes beyond taking a peek into our small bag of examination tools is understanding how to use those tools and, in particular, the correct order of use. The patterns of injury vary from childhood to old age and examination is modified to suit the developmental attributes of the patient. These variations will be discussed as they arise.

EXAMINATION AND THE ACUTELY INJURED PATIENT

In theory, clinical examination is an orderly process: it has to be systematic so that nothing is overlooked. Examination of patients with fresh injuries can make this difficult. They may be bleeding, vomiting or feeling faint; they may be immobilised by swelling and unable to walk. They are likely to be in pain, anxious and vulnerable, and they are often embarrassed. In spite of this, patients are expected to let you ask personal questions, intrude upon their space, expose and handle their bodies, and provoke their pain.

The examination of the acutely injured patient is based on the priorities at that particular moment much more than, for instance, a physiotherapist's or an orthopaedic surgeon's examination of the same patient 3 days or 6 weeks after injury. Is this an emergency? Is this really an injury or is the patient ill? How bad is the pain? Who will look after the patient tonight?

If you can carry out a full examination, arrive at a diagnosis and complete the patient's treatment on the spot, that is ideal and it should be done. If that cannot be done, decide what the situation requires.

The clinical examination will indicate what injuries are possible and the urgency of diagnosis. It may be possible to exclude a fracture in a finger but not to test the soft tissues because of swelling: is it enough to send the patient away with advice on possible complications? Should the patient be referred to a specialist at once? Would someone else have access to extra resources which the patient should be receiving (such as anaesthesia or soft tissue imaging)? Should you review the patient on another day and if so when?

Much depends upon the local situation. If you work in a large centre you will probably refer any doubtful case at once. If you are miles from specialist help you will have other factors to weigh. The first priority is to make the patient safe. After that, the approach should be sensible.

You will have local policies for the review of patients who are not fully examined on a first visit. Delay will be pointless if patients do not know how to improve the injury. Give written advice. Exclude any serious diagnosis. Provide (and document) a 'safety net', advice to the patient which describes any recognised complications which would trigger a return to hospital before the time of review. A couple of days of rest, using crutches or a splint and treating swelling, often makes examination easier and the results more reliable.

The deferring of full examination is sensible and helpful in many cases but it can only work if you know what you are doing. Some injuries can only be treated during a small window of time and some will worsen over every day that they are untreated. Others are less time-critical and can happily wait for a few days or weeks. Assess each injury for its hazards, for its differential possibilities, and plan the patient's care accordingly.

Restrict examination of an acutely injured patient once it is clear that he or she needs immediate referral. Assess the severity of the problem and make the patient safe and comfortable. It may be possible to speed things up by arranging, for instance, an X-ray. At that point, there will be no reason to examine the patient further. It will cause pain and the patient may be less cooperative later for further examinations.

Think carefully when the patient is a child. Minimise distress. If the child is safe but needs referral, pain relief and reassurance are the priorities. If the child is upset, the next examiner will start at a disadvantage. Anticipate the problem and refer at once.

THE ORDER OF EXAMINATION (BOX 5.1)

There will be a good deal of discussion below about different aspects of musculoskeletal examination. This section will look at an overarching issue, the structuring of the individual examination techniques into an organised consultation with two objectives, making a diagnosis and placing the injury on a scale of severity:

- Three tissues are at the centre of musculoskeletal limb assessment, bone, muscle and ligament. Examination is usually structured around the simple 'look, feel, move' approach, sometimes known as the 'orthopaedic system'.
- **Look** is always the first step but **feel** does not always come before **move.** Muscles and ligaments in the limbs have a tendency which is greater the closer to the midline that they lie, to the neck or lower back, to **refer** pain. Pain referral will be discussed below: here, all that we need to say is that a referred pain is one that is felt in the wrong place. This means that the patient may point to a painful elbow when the injury is actually at the shoulder. It will be fruitless to palpate the elbow if the injury is in the shoulder. The way to locate the injury is to begin in the midline, at the neck or back, and work outwards and downwards, testing movement. When a movement makes the patient's pain better or worse that movement is using the injured tissue. If the pain is referred then it is quite possible that a shoulder movement will trigger pain at the elbow. You will now be able to zoom in on the shoulder and find the culprit and, at this stage, palpation, 'feel', may be useful. Therefore 'look, move, feel' is sometimes the way to go.
- Another key issue in your consultation is the point in the examination where you request an X-ray. There are two relevant factors: the first one is that bone, unlike muscle and ligament, *does not refer pain*. This means that 'feel' is a much more significant contributor to a bone examination than to an examination of the soft tissues because a bone will hurt in the place where it is damaged and when you touch it on that spot it will be tender. This fact is implicit in guidelines like the Ottawa rules for X-ray-requesting at various limb joints where palpation tends to be the dominant feature.
- There is a direct diagnostic connection between movement tests and soft tissue injuries which is not so clear with bone. Patients with similar fractures can have different ranges of movement around the injury depending on pain tolerance, small

Box 5.1 The rule of threes for injuries to limb

MINOR INJURY: limb, midline, referred
PRESENTATION: sick, injured, overuse injury
PATIENT: child, adult, elderly
PHASE OF INJURY: inflammation, proliferation, maturation
TISSUE: bone, muscle, ligament
EXAMINE: look, feel, move
MOVEMENT: active, passive, resisted
FINDING: diagnosis, differential diagnosis, management pathway
COMPLICATING FACTORS: nerve root pain, referred pain, the capsular pattern
SEVERITY: grades 1, 2 and 3
MANAGEMENT: discharge, rehabilitation, surgical referral

variations in the injury and other factors. Whereas, if the patient has completely torn, for example, the deep flexor muscle which bends the tip of the index finger, the fingertip will lose that movement and there will be a direct connection between the movement loss and the diagnosis. If a patient tears the anterior cruciate ligament of the knee then the tibia will move unnaturally forward from the femur in a way that will allow you to diagnose the injury and probably to grade its severity at the same time.

- If a patient falls on the lateral shoulder and has a huge swelling over the deltoid muscle, a lack of movement at the site can be caused by fracture or by a crush injury in the muscle among other soft tissue possibilities. Given that a necessity of clinical examination is to isolate one tissue in each test, in other words to know what you are testing and also to know what you are *not* testing, a movement test before fracture is excluded makes the test invalid for diagnosis (although it may give some indication of severity). We have already established that palpation is helpful for examining bone: it makes sense, for this shoulder injury, to assess the humerus and clavicle by palpation, X-ray the shoulder if it is significantly tender, and then assess the soft tissues by movement when we know that there is no fracture. If there is, for example, a fracture of the surgical neck of humerus, we can also avoid extensive movement tests which cause the patient unnecessary pain, given that the X-ray will determine the patient's management and the range of movement will not. If there is no fracture we will be able to test the soft tissues by movement, confident that we have already ruled bone out of the equation. Thus, the use of X-ray at the right time in the examination allows us to isolate, first bone, and then the muscles and ligaments, and this takes us to our objective, diagnosis and the grading of severity. It is very common in emergency areas to see examinations where everything is tested before X-ray and much of the patient's painful exertion has no value or is unnecessary because it does not inform the diagnosis (and it may obscure the diagnosis) and it does not influence subsequent management of the injury.
- A summary of the above discussion is that it is often useful if a patient presents with limb pain and no history of injury (in other words, no likely fracture and a possibility that the pain is referred from a soft tissue) to examine 'look, move, feel': if there is a history of injury then 'look, feel – *X-ray* – move' might offer best value for diagnosis. There are many cases where you would ignore this advice but it is broadly applicable and it illustrates the importance of planning every examination so that you test the different tissues around the injury one at a time. You will, in particular, achieve less than you should if you try to examine the soft tissues without knowing whether or not the patient has a fracture.

FRACTURE (BOX 5.2)

Examination of an injured patient often begins with the question of fracture. Aspects of examination of the patient with a possible fracture are:

- fracture first
- signs and symptoms
- assessment.

Fracture first

A patient with a violent injury may present with pain, swelling, bruising and disability. Certain signs are more specific. An abnormally angled bone is broken. A fracture may be visible in a wound. In most cases the signs are less specific. It may not be clear whether the patient has injured bone or soft tissue. The diagnosis is reached by exclusion, beginning with fracture.

Fracture comes first for several reasons. It is often the easiest injury to exclude by X-ray. A fracture is painful, and it should be found with a minimum of discomfort to the patient. The examination and treatment of soft tissue injuries is different to that of fractures, and a negative X-ray may allow the assessment to proceed without confusion. This has been discussed in more detail above.

Signs and symptoms

Many of the appearances of fracture are not specific to fracture alone.

There will normally be a history of injury. Exceptions are stress fracture (with a history of overuse rather than violence) and pathological fractures (with, perhaps, a suggestive medical history such as cancer or osteoporosis). There will be clinical signs of fracture.

Box 5.2 A road map through assessment of the injured patient

- Exclude fracture and dislocation
- Assessment of the soft tissues by active movement
- Further movement tests to decide which tissue is injured

In the case of an open fracture, the broken bone may be protruding from, or be visible in, the wound. In cases where a bone pierces the skin and then retracts back inside the limb the wound can be very small and its cause may not be immediately obvious. Open fractures are at risk of contamination and infection and always need to be picked up. Always look for broken skin around an injury and think carefully when it is found.

The most specific sign in closed fractures is deformity. The bone may be shortened or widened by impaction or overlap; it may be lengthened by separation of the broken ends; it may be rotated or angulated. It can be difficult to distinguish between the deformity caused by a dislocation and a displaced fracture, and the two may coexist.

Also specific is **crepitus**, a grating from the movement of broken ends of bone upon each other. This sign may be mentioned by the patient or accidentally elicited but it should never be directly sought. The deliberate mobilising of broken ends of bone may cause more damage around the site, and it will cause the patient severe pain. On occasion it is reasonable in examination to subject a bone to an angular or axial stress, which might elicit crepitus, but you should only really do that to demonstrate your reasonable certainty that the bone is not broken, not that you believe that it is.

Abnormal movement may be a definite sign of fracture depending on its site. Dislocation and ligament injury can cause this sign at a joint.

Among the general signs and symptoms of fracture are **pain, bruising** and **swelling, local tenderness, restricted movement** and **disability**, and **guarding** of the injured part. The patient may be shocked because of blood loss and pain.

Assessment

Fracture may involve displacement of bone, with injury to nerve, blood vessel and any organ. Assess colour and warmth, pulse, capillary refill time and sensation distal to the injury, together with the patient's vital signs if that is necessary.

Broken bone bleeds and is painful. The patient may be in shock. Is he or she restless, pale, cold and sweaty? Is the breathing rapid and shallow? Is the patient sluggish? Monitor vital signs. Does the patient need oxygen, intravenous fluids and analgesia?

If a fracture is unstable, the injury may worsen and movement may cause severe pain. Use splinting and examine with caution. Neurovascular compromise and compartment syndrome are among the possible complications.

The mechanism which causes injury at one site may tend to cause simultaneous injury at another. The areas affected may be close to each other (eg, the radius and ulna) or widely separated (eg, calcaneal fractures caused by landing on the heels from a height correlate with injuries to the spine).

Fracture may coexist with other presentations (eg, subungual haematoma, mallet finger and dislocation). Such fractures will usually alter the management of the injury and it is important not to miss them.

Aspects of examination

The process of musculoskeletal examination, which includes fracture, is discussed later in this chapter. A few points are discussed here about fractures in particular.

Fractures are mechanical events caused by violence and the mechanism of injury is of particular importance. The possible injuries are determined by the forces which have been applied to the tissues. Examination of the patient in the light of the mechanism of injury means that you will exclude any injury, anywhere in the body, which that mechanism can cause, regardless of the patient's actual complaint. It may be enough to watch the patient walk in from the waiting room to settle some concerns. Detailed examination is usually started from the joint above the injury. If a patient has a painful wrist after a fall on the outstretched hand, ask to see both arms above the elbows and examine from elbow to fingertips. Confirmation that the patient is using the shoulder normally can be achieved by asking him or her to raise a hand behind the head and then to put it up the back. Suspicion of undisclosed injury should be greater with patients who are elderly, have learning difficulties or mental illness, are intoxicated, and with children. The suspicion of non-accidental injury will also cause you to reconsider the history you have been given.

The need to X-ray

It has already been said that palpation is the main tool for seeking fractures and tenderness is the usual indication for X-ray. However, tenderness can be a non-specific sign. When you press on swollen skin and elicit pain you cannot be certain what tissue is causing that response. McRae (2010) advises on how to improve your certainty that it is arising from bone. A broken bone will be tender at the level of the fracture on every aspect of the bone. Remember that if a fracture is a spiral it will cross the bone diagonally and be tender at different levels on different sides of the bone. If tenderness is confined to one surface of the bone, then it is less likely to be caused by a fracture. We tend to have our favourite surfaces for examination. For example, we examine the metacarpals of the hand on the dorsum and this indeed is the best way to do it. But if there is tenderness on a metacarpal shaft, ask the patient to turn the hand over and press the same place on the palm side. Tenderness on both surfaces increases the likelihood of a fracture.

If a fracture is an avulsion (a fracture caused by sudden stress on a soft tissue such as tendon or ligament which causes it to pull off its bony attachment point) then it will not be tender on all surfaces of the bone. You will become familiar with the key points where these fractures tend to occur.

Axial loading along a bone, pressing it from one end towards the other, can be helpful as an indicator of fracture if it triggers pain in some part of the bone which is distant from the part that you are holding. This is only helpful if the surrounding soft tissues are not stressed by the manoeuvre. It must be done carefully and selectively: if a fracture is undisplaced you do not wish to change that by rough handling.

Children have softer bones than adults and fractures are common. Children also have growth plates which are even softer than the bones; if the physis is tender after injury you must consider the risk of growth arrest. The anatomy of young bones is an important part of your education.

Guidelines such as the Ottawa ankle rules (Stiell et al 1993) attempt to identify patterns of tenderness which are associated with fracture. These are of particular value for the ankle because we request so many negative X-rays of that joint.

Guidelines on diagnosis of fractures are generalisations, and patients will always be found who do not fit them. Local tenderness is always present with a fracture but it can be difficult to elicit in some elderly patients with fractures of the distal forearm (while others, with arthritis, have a great deal of tenderness and no fracture). Children with greenstick fractures may have no bruising or swelling. An alcoholic with peripheral neuropathy who has been drinking heavily can walk about on a badly displaced ankle fracture for days or even weeks. Consider this when deciding whether or not the patient needs an X-ray.

MUSCULOSKELETAL EXAMINATION

We will now look at the general principles of musculoskeletal examination, with a special emphasis on the soft tissues:

- preliminary observation
- history
- physical examination
- complicating factors in examination.

Preliminary observation

Formal examination is a revealing process, but it does not always highlight the problems which the injury causes the patient in daily life. It will help you if you can see the patient in the waiting room. Assess movement, appearance and conduct as the patient gets up and walks to your room. How easily does he or she move? Where do any restrictions or difficulties arise? Is the patient in pain, pale, cradling an arm or limping? Does the patient use the injured part? Are the social responses comfortable, are they agitated or lethargic?

The patient should be seen in a quiet, private area. The fact that it is a minor problem does not reduce the right to confidentiality and small injuries are occasionally a feature of larger issues. The patient may have to undress. Patients with minor injuries are often treated, more for lack of space than any view that it is desirable, in curtain-divided cubicles where there is no privacy of speech, and where physical modesty is casually affronted.

History

The taking of a history has been described and the importance of a clear history of injury has also been discussed.

If the patient has suffered a violent injury, the mechanism should be established and you should have a clear mental picture of the whole episode. The patient may not understand the need for, or be able to give, a full history. Ask questions until you know as much as the patient knows about how the injury happened. Every physical factor contributes to the picture: direction, speed and duration of the force, the type of surface, height of fall, position of limbs and the direction in which they moved. Match the story to the clinical appearance. If they are not consistent, go back to the beginning. The patient may be rationalising a false connection between an incident and the symptoms.

In many cases the patient complains of an onset of pain with no history of injury, which makes assessment harder. It is often possible to relate an overuse injury to a pattern of daily activity which explains the symptoms. However, in other cases medical problems surface in an MIU. The patient complains of pain and may relate it vaguely to injury. You have three responsibilities: first, to know when a problem may not be an injury; second, to recognise the most serious possibilities so that an emergency will not be mismanaged; and, third, to make accurate referral so that the patient can be properly treated:

- **Pain** is important. How does the patient describe the pain? Was pain immediate or delayed? Is it getting worse? Is it constant or intermittent? Does anything relieve or aggravate it? Is it related to movement and does continuing movement worsen or improve it? Does it disturb sleep? Is it worse at any time of day? Is it travelling to parts which were not injured? Is it associated with numbness or tingling or is there weakness?
- Questions can also clarify events around the time of the injury. Did the patient hear or feel cracking or tearing? Was a joint forced into an abnormal position? Was the patient able to walk after the

injury and has walking improved or worsened since? Was there **swelling**? Was it instant swelling (of a haemarthrosis) or a slower synovial effusion? Has it worsened or improved? Does it come and go?

- Further questions elicit facts about the injury's continuing symptoms. Has the patient noticed any **stiffness**? Is movement limited? What limits the movement? Is it pain, or the expectation of pain, or is movement blocked? The patient may describe 'locking'. What is meant by that? Is the joint still locked? If not, what happened to unlock it?
- The patient may describe a feeling of **instability** in a joint, often in terms of the joint popping out or giving way. Did the joint pop back, did the patient manipulate it? Ask for examples of where and how, how long, how often and during what movements.
- How does the problem affect the patient in **daily life**? What can the patient *not* do? The answers are important, not only because they tell more about the injury but also because the replies indicate the attitude to recovery and the level of activity that the patient expects to resume.
- Yet more questions on what **treatments** the patient has tried give an indication as to whether it is improving. Has the patient used ice or taken painkillers? Did any of these help? Has the patient been resting or active since the injury? A large swelling may be quite differently interpreted if the patient has been playing football on a freshly injured ankle.

Physical examination

The patient should undress to show both the area to be examined, and the opposite healthy area. Examination will normally be from the joint above the injury. The patient's modesty should be preserved and there may be a need for a chaperone.

Make the patient comfortable in a position which allows effective examination. This may be sitting at a small table for hand examination, standing for shoulder comparison or lying on a couch with an injured knee. The injured part should be supported so the patient can relax. This may involve the use of pillows and cushions.

Examination of acute musculoskeletal problems is structured around the orthopaedic approach: look, feel, move. Examination always begins by looking. The order of the other parts of the process, as has been discussed above, varies.

If the probable injury is a fracture, palpation or 'feeling', followed by X-ray is often the best approach. It is possible that you will defer an assessment of movement until after the X-ray. Clinical guidelines on when to request X-rays for specific injuries, like the Ottawa ankle rules (see Chapter 11), place heavy emphasis on the presence or absence of tenderness because bone does not refer pain and it is reliable in showing tenderness where it is injured. This is not always true of the soft tissues. It is also the case that the chief tool for assessment of the soft tissues is movement, but the significance of a movement examination is much clearer if the issue of fracture has already been settled. A reasonable rule is that if you have already decided, after a palpatory assessment, that an X-ray is required, carry that out before going on to assess movement.

The order of examination may also depend upon which part is injured. If the patient is lying down for examination of a painful knee, it may be better to perform the whole face-down part of the examination at one time so that the patient is not constantly struggling from one position to another. In some cases, the diagnosis is clear from the start and the examination is tailored to the variations of that problem. Injuries such as dislocation and mallet finger are often in that category. In other instances, it may become clear that a certain diagnosis is not possible and examination can be confined to what is relevant.

If the injury seems to be one of soft tissue, movement may become more significant in the assessment, and palpation for tenderness may even be misleading. Pain from injury to soft tissue or to nerves may be felt a long way from the damaged part. The methods of discovering which tissue is injured are based, first, on knowledge of how pain refers, and, second, on tests of the function of those tissues which may be injured. These are tests of movement.

A physiotherapist often begins examination of a patient with a musculoskeletal problem by testing movement and may only use palpation to confirm the findings. A rheumatologist, confronted by a patient with a history of joint pain, may give palpation a larger place in the examination. You will develop skills in palpation and the assessment of movement, and aim to apply them in a discriminating and appropriate way.

Look

'Look' does not mean 'glance' or 'what you do with your eyes while you reach out to prod that interesting lump'. Looking is a separate, reflective process carried out over a period of time in a structured way. It involves notions like compare, measure and describe. Looking is sometimes the part of the examination which delivers you the diagnosis.

Injuries which involve displacement or deformity are usually evident to the eye. Chronic injuries which cause wasting, contracture and deformity leave strong visible traces. Each joint has its own typical patterns of change when injured. The shoulder is relatively unstable and the arm hangs in mid air, so that there is a strong tendency for it to literally fall apart when badly injured. It does not,

however, show redness or swelling to the same extent as the knee because the shoulder lies under layers of muscle while the knee is superficial. Swelling at the knee can be subtle, and you will always wish to compare the two knees. Swelling at the outer side of a sprained ankle, on the other hand, is usually conspicuous, even when the swelling is not large, and it is usually superfluous to request a view of the uninjured side. You will become skilled at seeing the normal and the abnormal at each joint.

Make use of all available lighting, and position the patient so that light is distributed evenly, preferably from directly overhead. If the body is lit unevenly the hollows and bulges where swelling and wasting tend to be seen lie in different depths of shadow and this can make subtle comparisons more difficult.

Looking starts with general observations; of the patient's wellness, alertness, posture, gait and symmetry, colour and breathing.

Look at the area to be examined and the surrounding area, either by walking around the patient or by asking the patient to turn. If the patient is lying down, ask the patient to turn over at some point in the process. It can feel socially awkward to do this. Both you and your patient will feel more comfortable when you are in eye contact and there is a sense that you are treating a person as an object when you walk around them. This should not inhibit you from looking at all sides of the body: the signs of injury do not confine themselves to one surface.

Compare the injured with the uninjured side. Note any bruise, redness, rash, wound or scar. Is the skin dry, clammy, flushed, blue, pale? Is there swelling or wasting? Is the swelling localised or widespread? Is there deformity? Is the deformity bilateral? Does it arise from joint or bone; is it traumatic, degenerative or congenital? What is the posture of the joint? Is there rotation or shortening?

It is surprising how long you may look at an injury before seeing a feature such as swelling or redness, which then seems obvious.

Feel

Looking at the patient does not inflict pain, and the patient is in control and can limit discomfort during active and resisted movement. It is harder for a patient to submit to palpation and passive movement. Show, by words, by arrangements for the patient's comfort, and by the care, confidence, restraint and skill of your handling, that you can be trusted with these tasks. Otherwise, the patient will not relax and any reactions will be distorted by anxiety.

Palpation is a systematic exploration by touch of all the accessible structures related to the injury. It is perhaps helpful to think of it as an extension of the looking process. You will feel, as you will see, certain abnormalities, but there is more to it than simply pressing something tender and eliciting pain. Clinical activity is about ways of discovering what is happening in tissues which are hidden from us within the body, and you should learn how things feel in the same way as you learn how they look. It is not enough, for example, when examining a painful wrist, to prod a fingertip vaguely in that hollow which is called the anatomical snuffbox, and to decide that the patient needs scaphoid X-rays because there is tenderness. There are many reasons why an injured person may be tender in that area. The scaphoid is very mobile, and you can quite easily put your finger into the snuffbox and have no contact with the bone at all. The starting point for a sound examination is to learn how to identify and explore the scaphoid with your fingertips.

Examination will generally include the area from the joint proximal to the injury to the joint beyond, and the circulation and neurological function of the area distal to it. The back of the hand is more sensitive to temperature variations than the palm. The exploration will be more informative if it is performed gently. Compare with the unaffected side.

Some structures, such as the articular surfaces of the knee, can only be felt with the limb in certain positions. Other structures are exposed by palpation during passive movement. The scaphoid will bulge under the finger if you press into the anatomical snuffbox while passively moving the patient's hand into ulnar deviation. Crepitus, clicking and other interruptions to normal movement in a joint or tendon sheath will only be felt by moving the part. Elicit these signs gently. Do not look for crepitus from broken bone.

Explore the anatomical landmarks in an orderly sequence. The finger pads are more sensitive, and gentler, than the tips. Use them lightly. Feel for each layer of tissue from skin down to bone. The rubbery texture of a thickened synovium at the knee can be felt by lifting the skin and gently rolling it between the fingers.

A tender area should not be directly prodded. It is helpful, with an injured muscle, to begin palpation proximal to the tender spot and move distally until the patient feels the beginning of pain. Draw a line there. Repeat this procedure from the other three directions so that a rectangle of tenderness is outlined without causing more than mild discomfort.

Note the qualities of any swelling. Is it general or localised with clearly defined boundaries? Is it hard or soft, tense or fluctuant, mobile or fixed? Is it anchored to a particular tissue?

A loss of **continuity** may be felt in a tissue, at the displaced end of a fracture or a gap in a muscle or tendon.

The area may feel **hot** or **cold** compared with the normal part.

Note any **tenderness**, but its significance should not be assumed (see movement). Some tissues are normally tender to palpate, so they should be compared with the uninjured part.

Check **pulses** and **sensation** in the injured area and distal to the injury. Light touch is usually tested for a quick assessment of sensation.

Move

Joint movement is measured precisely with a goniometer. This level of accuracy is most valuable for patients with chronic conditions, whose progress can be charted effectively. It is not normally necessary for patients with acute injuries. Nevertheless, you will make some estimate of movement loss with the larger number of your patients. There are also many occasions, for example when a patient is referred to a physiotherapist, when a baseline range of movement, recorded at the first presentation, will be valuable. It is therefore useful to develop a simple but reasonably accurate way of describing the patient's range of movement.

Joint movement is measured in degrees, from the anatomical position as zero. There are textbook normal ranges for each joint, and the patient's uninjured side shows what is normal for that individual. Apley and Solomon (1997) advocate a simple system for describing the range of movement, the consistent recording of the range in degrees whether or not a goniometer is used. Movement in a knee which has lost 5 degrees of extension and about half of its range of flexion is recorded as 'knee-flexion – 5–70 degrees' (a normal range is recorded as 'knee-flexion – 0–140 degrees'). If, as is often found at the knee, the patient has a greater than normal range of movement, this can be recorded as a minus reading. For example, if a patient can extend the knee 5 degrees beyond the normal, the range can be recorded as 'flexion – minus 5–140 degrees'.

The musculoskeletal system is designed for movement. The key concept which underpins the process of clinical examination and diagnosis of the system is that an injury will affect movement adversely. If a patient has a full range of movement with no evidence of pain or disability, there is nothing wrong with the musculoskeletal tissues. Movement is of greater significance for assessing the soft tissues than palpation because the soft tissues can refer pain. If the site of pain is not the site of the lesion, then it is difficult to make a reliable finding with palpation. A systematic assessment is therefore used to discover which active movements make the patient's pain worse, or, equally significant, relieve it. Once that has been done, further tests of passive and resisted movement will reveal whether muscle or joint structures within that movement are causing the problem. Once the diagnosis is reached a plan of management can be based on the grade of severity which you assign to the injury (see Chapter 4).

This means that movement must be tested in a very structured way. Before you embark on examination, you have to learn the relevant anatomy related to each movement. In particular, you must know the muscle and joint structures which are normally involved in injuries around any given joint. Each movement is then performed by the patient in a pure way so that your knowledge can come into play.

Patients will unknowingly find different ways of carrying out restricted or painful movements. A patient who cannot initiate abduction at the shoulder will tilt the trunk to the painful side so that the arm falls away from the body by gravity. A patient who cannot flex the shoulder will allow the arm to drift sideways into abduction. Some forms of this **substitution** of one movement for another are subtle. In patients with chronic problems, there may be long-established mechanisms of this kind.

There are examination techniques in common use to make quick functional assessments of movement, such as asking a patient to touch the back of the head with the hand, and then to put the hand as far up the back as possible, to show that the shoulder is pain-free. These tests are useful to clear a joint quickly when you think that it is uninjured. They are not adequate for diagnosis of specific injuries because they combine too many movements. Your ability to diagnose an injury will depend on narrowing down the range of tissues which might be injured to a very few, and on your knowledge of those tissues and how to test them.

Testing of movement is carried out in stages, each with distinct techniques and objectives:

- active movement
- passive movement
- resisted movement
- stress testing and accessory movement.

Active movement

The patient performs **active** movements unassisted, mobilising the whole musculoskeletal system. Difficulty with active movement can arise from disease and from injury to bone, nerve, muscle or joint capsule. Active movements do not isolate the injured tissue. They narrow down the search to the structures which are used during single movements which are painful or restricted. Once we know which movements are problematic we can use passive and resisted movements to isolate the tissues involved in those movements.

A sequence of movements, different at each joint to show its full range of movement, is measured to test the bones, the muscles which move the bones around the joint, and the joint itself. Any limitations should be noted and the patient asked to describe what is preventing movement: pain, weakness, 'tightness' or 'locking'. In some cases, for example where an 'arc of pain' (see Chapter 6) at the shoulder is suspected, encourage the patient to push on through the pain to find out if movement becomes painless again in the upper part of the range. Record the active range using the method described above.

If the active range of movement is complete and comfortable in one movement, you can **overpress** the movement. Overpressure is the difference between the patient's active and passive range in a given movement. The passive range is always greater than the active in any movement. Overpressure is used because there is no need to carry out a full passive movement when the active one is intact. Gentle pressure applied by you takes the joint from the end of the active range to the end of the passive, where the joint tissues are stretched to the point of tightness. This completes the assessment of both types of movement and **clears the joint** for that particular movement.

The uses of passive and resisted movements

In this part the principles for isolating muscle and joint tissues for examination are described.

Musculoskeletal examination for patients with minor injuries is broadly about examining three structures, bone, muscle and ligament (ligament being the part of the joint which is most prone to significant injury). The condition for a valid examination is that you know that a given technique tests a given tissue and, crucially, that no other tissue is being tested at the same time.

We have already seen that palpation followed by X-ray is often the best way to isolate and eliminate bone as a source of injury. Once bone has been eliminated, you only have two tissues to test, muscle and ligament.

Injuries to muscle and ligament can refer pain to areas where no injury exists, usually distal to the actual lesion. Injured tissues which lie deep, and those in or near the trunk, are the most likely to refer pain and the hardest injuries to locate. Referral of pain is discussed below. At this point, the key fact is that palpation is not a reliable way to locate such injuries. Firstly, the patient may feel pain from the injury in a place which is not injured. Secondly, a lesion which lies deep may not be palpable. Finally, unlike bone, an injured soft tissue may not be tender when palpated but may only be painful when it is stretched or pinched during movement.

Active movements can reveal that an injury is present in a given area of the limb but they do not distinguish between damage to bone, joint or muscle. In an MIU you can rule out injury to bone at the outset, either because the history does not suggest it or because an X-ray excludes it. Passive movements can then test the inert tissues at the joint of which the most injury-prone are the ligaments. The patient does not use muscles during the movement and, because they are relaxed, they do not cause pain. You, the examiner, have, for a few moments, *become* the patient's muscles.

Resisted movement tests muscle. Ironically, tests of resisted movement must take place with an absolute absence of movement. The muscle contracts so that it is working hard but it is exerting itself against an immoveable obstacle provided by you. Thus the joint does not move during the test and this eliminates it so that any symptoms are likely to be caused by muscle.

Injury may show as pain and disability. Weakness is the sign of disabled muscle, laxity of ligament. Laxity will sometimes cause a patient to complain of a feeling of instability in the joint. Torn cartilage, and occasionally other material lying in the joint, can cause locking: this is the inability to complete a movement because of a mechanical obstruction of the joint. There will be some evidence of the damage which the tissue has suffered, and this finding, rather than palpation, is the reliable pointer to the part which is injured.

Passive Movement

Overpressure and the relative range of active and passive movement have already been discussed under active movement.

There are different types of passive movements and passive movements can be used for different purposes. You are using them here to test the joint while avoiding stress on the muscles. If the patient has an injury to a joint structure which has caused the joint to swell and become inflamed, a passive movement which replicates the patient's restricted active movement will also be restricted, and to the same extent.

Sometimes a joint structure may be injured without causing generalised swelling and inflammation in the joint. In that case the active and passive range may be normal, but another form of passive movement called **stress testing** will reveal the injury. Stress tests are movements which, instead of replicating ordinary joint movements, impose movements on the joint which are normally prevented by ligaments. If the ligament is uninjured the test will show a normal firmness in the ligament. If the ligament is torn there will be laxity, abnormal and unstable movement. Stress testing is discussed below.

Standard passive movement aims to eliminate the muscle, the tendon and the tenoperiosteal junction from the test and to stress inert tissues such as ligament and cartilage. It is of particular value when bone injury has already been excluded. The examiner lifts the injured part and takes the joint through the same movements that have already been tested actively. The patient relaxes muscles so that they are not leading the movement.

If the patient's range of movement is no better than on active testing, and other symptoms remain, then an inert tissue such as ligament or cartilage is the likely cause of the problem. If the range of movement is increased, and the symptoms are less, then it is more likely that the trouble arises from muscle.

Make the patient comfortable as it is difficult for patients to relax to the extent which is necessary. The patient may not be in the same position as when the active range is performed. For example, active shoulder movements may be

tested when the patient is standing and passive movements tested with the patient lying down. Lying down enables the patient to relax and the examiner can handle the arm more easily in its elevated positions.

As you will discover if you undergo it, passive testing is a strange experience, quite unlike anything else: it is an invasion of our physical autonomy to have a stranger moving our limb for us at any time, more so when it is injured. It is also not so easy to understand why or how it is done as it is with active or resisted movements. Patients need a clear explanation of the purpose of this procedure, and reassurance that it will be performed gently, and that their responses will guide the extent of movement.

Passive movements can be adapted for purposes other than joint testing: they can also be used to stretch muscle. Your passive tests in this context are aimed at isolation of the joint and must be carried out in a way that avoids the involvement of a muscle. For example, if you try to passively flex the hip with the knee straight, the patient's hamstrings will tighten before you stretch the joint. Perform the movement with the knee bent to relax the hamstrings.

At the point where the passive stretching of a joint ends, the **endfeel** should be assessed. Each joint movement ends in a typical way which is the same for that movement at that joint in every patient, but not necessarily the same as other movements at that joint, or the movements at other joints. A passive movement will continue until something stops it, and the examiner can gain some sense of whether or not the agent of the stoppage is the usual one. If it is not, there is something wrong. The classic example of the link between endfeel and diagnosis in minor injuries is found in knee examination: for passive extension, the straight knee is lifted into slight flexion by the examiner and then dropped into extension with the examiner's hand still in contact with the back of the joint. The knee should drop into the hand with a firm thud. Instead, it rebounds in a springy way just before it reaches normal extension. The examiner experiences this endfeel in the hand which touches the knee. In this case it indicates a possible meniscal tear. The joint is obstructed by rubbery stuff. An endfeel which is normal for one movement may indicate something abnormal if it is found at another:

- A **hard** endfeel is caused by bone meeting bone (eg, elbow extension). This can be an abnormal finding if the movement is restricted or if that endfeel is not normal at the joint being tested. It suggests the presence of some extra growth of bone.
- A **capsular** endfeel is firm with a hint of stretch, indicating that the movement has been ended by the resistance of the ligaments (eg, shoulder rotation). This endfeel is abnormal if the movement is restricted. Such restriction may indicate arthritis, chronic effusion or contracture of the capsule.
- The meeting of the posterior thigh with the calf when the knee is flexed stops that movement with an endfeel which Cyriax calls **tissue approximation.**
- A hard **twanging** endfeel is caused by muscle spasm. This is abnormal and may be triggered by the presence of arthritis or a severe ligament tear.
- A protruding meniscus tear at the knee or a loose body in the joint may cause a **springy block**, preventing completion of normal extension of the joint with a rebound as if there is a little rubber ball lying in the joint.
- An **empty** endfeel means that the patient stops the movement because of pain, or the expectation of pain. This suggests an acute lesion which is severe and may be serious.

Accessory Movement and Stress Testing. Accessory movement and stress testing refer to passive tests at the joint of movements which the patient cannot perform voluntarily because they are not under the control of the muscles:

- **Accessory movements** are slight movements which the joint allows, sometimes called **joint-play**, as a result of normal laxity in the capsule. They are tested in the loose-packed position. They are an important aspect of normal movement. A hypermobile joint lacks stability. A hypomobile joint is restricted at the extremes of its range of movement. **Stress testing** is the passive stretching of ligaments to detect injury. An acute minor tear will be painful when the ligament is stressed but not lax. A larger tear will show pain and laxity. A complete tear may be shown by pain-free laxity.
- Accessory movement is tested when active and passive movements are limited but resisted tests are normal. The patient is shown the loose-packed position for the joint and the examiner uses two hands, placed close to each other on either side of the joint. One of the bones is stabilised with one hand, and the other hand applies traction to open the joint and separate its surfaces. Rotation, rocking and gliding movements may also be used. Accessory movements are often tiny and hard to assess. The patient's range on the normal joint is the best guide. The endfeel will usually be capsular, whether the joint is normal or not.
- Stress testing is done in the position which best isolates the individual ligament. The result will not be reliable if the patient has muscle spasm around the joint because of pain or instability. The endfeel may be capsular with a normal ligament; empty with pain, if it is sprained; empty without pain, if gross laxity is present after a complete tear; and hard, or 'twanging', if muscle spasm stops the movement.

Resisted Movement

Resisted testing, with no movement at the joint, isolates muscle and tests the contractile tissue and the tendon.

On occasion, problems other than muscle injury may cause pain with resisted testing (eg, fracture, tumour, infection, or an inflamed bursa compressed by the muscle). In some of these cases, there are other indicators which help with the diagnosis. These may be found in the history or in appearances such as fever, redness and heat, tenderness, and pain on passive movement. In other cases, the pain does not restrict itself to the action of one muscle. In practice, these complaints often announce themselves by other signs and symptoms. There has already been discussion of the benefits of excluding fracture from the range of possible diagnoses before undertaking movement tests. It is certainly hard to see why resisted tests would be done before a necessary X-ray.

Each joint has a **loose-packed** or **resting** position, where the joint capsule is at its most lax. A joint will tend to seek a loose-packed position when it swells because there is more room to accommodate the fluid. The elbow seeks a position of around 90 degrees of flexion when it swells, a position which you will have seen on many occasions if you treat injuries. There is benefit in having the elbow at this position because it is easy to support in a sling. It is equally fortunate that the knee seeks a position of only a few degrees of flexion when it swells, so that the patient can put a foot to the floor, even if the heel is raised.

The loose-packed position, or something near it, is recommended by Cyriax for resisted testing because the inert tissues will not be stressed. Conversely, the **close-packed** position, when the joint surfaces are close together and the ligaments are tense, is less suitable. As a generalisation, joint tissues are lax in the mid position of the joint and tense at the extremes of their range.

One hand is used to stabilise the patient. The other offers resistance in the opposite direction to the movement which the patient will attempt. The patient begins an isometric contraction of the muscle against your increasing resistance and increases it until full force is exerted. The patient then gradually relaxes as the examiner reduces resistance. At no point in the test should actual movement occur. If it does the test is invalid.

There are recommended positions for tests of every joint and muscle: these tests are illustrated in the chapters on the individual joints. In general, the position of the resisting hand should be fairly close to the joint. If it is placed on the far side of a second joint (eg, resisting shoulder movement by pressure at the wrist) then the test will include muscles at both joints. It may not be clear where symptoms are coming from, and if the elbow is weaker than the shoulder in that movement, the shoulder will not be fully tested. It is sometimes useful to place the resisting hand a long way from the test joint if the patient is much stronger than the examiner, literally to give the examiner some extra leverage. There can be problems when a small examiner is testing a large athlete.

There are two abnormal findings, weakness and pain. Cyriax interprets the combinations as follows:

- A **strong, pain-free** muscle is normal.
- A **strong, painful** muscle has a partial injury which hurts but does not reduce function (grade 1).
- A **weak, painless** muscle may have a complete tear of the belly or tendon, or there may be a nerve lesion (grade 3).
- A **weak, painful** muscle suggests a major problem (grade 2).

Complicating Factors in Examination (BOX 5.3)

The method of examination which has been described above may produce confusion if other considerations are not weighed in the assessment of the findings. There are three of these; two of them will be discussed below, in a section largely based on Cyriax:

- the capsular pattern
- referred pain.

The third consideration is nerve root pain and other symptoms arising from the spine. This is discussed in Chapter 14.

The capsular pattern

The word **capsular** refers to the joint capsule.

Certain changes in a patient's movement and posture after injury can be the result of a joint's response to trauma.

The joint is a meeting place for two bones, held together by a capsule made of membranes and ligaments: it is bathed

Box 5.3 The rule of threes for injuries to limb

MINOR INJURY: limb, midline, referred
PRESENTATION: sick, injured, overuse injury
PATIENT: child, adult, elderly
PHASE OF INJURY: inflammation, proliferation, maturation
TISSUE: bone, muscle, ligament
EXAMINE: look, feel, move
MOVEMENT: active, passive, resisted
FINDING: diagnosis, differential diagnosis, management pathway
COMPLICATING FACTORS: nerve root pain, referred pain, the capsular pattern
SEVERITY: grades 1, 2 and 3
MANAGEMENT: discharge, rehabilitation, surgical referral

in fluid secreted by its innermost membrane, the synovium. Each joint has a slightly different construction dictated by the range and type of movements that it must perform in that site. The interior of the joint changes shape during movement and the size of the joint space changes too. The joint space tends to get smaller at both ends of a movement because the bones come together and the tissues of the capsule get tight.

Injury tends to cause swelling in the joint, especially in the early, inflammatory phase. The swelling interferes with the joint's movements because there is only limited accommodation in this self-contained capsule for fluid. The joint moves to a position somewhere in the middle of its range of movement so that it can better cope with the extra liquid: it moves to the position where there is most space in the joint. This point varies from one joint to another. The capsule also becomes tense and bulging and less able to permit a full range of movement.

Other problems in joints, of which inflammatory diseases are probably the most numerous, cause a similar appearance but may also cause other changes in the tissues of the joint as well as the inflammation which accompanies a fresh injury. Infection can also cause an inflamed, swollen, painful joint.

A 'capsular pattern' of movement is therefore imposed on the joint by the presence of swelling and other features of inflammation.

It was Cyriax who coined the term 'capsular pattern'. It was one of his important observations that joint inflammation does not simply restrict every movement in a joint equally. He observed that inflammation affected a joint according to its shape and construction and that some movements were unaffected while others were much reduced. He described a pattern which is different for each joint but is the same for that joint in different people. When movement is reduced in the capsular pattern, the entire joint capsule is inflamed. Different forms of arthritis, haemarthrosis and frozen shoulder are among the complaints which can cause this restriction.

The capsular pattern refers to the joint and not the muscle: therefore, in keeping with the principles of examination described above, it is seen to the same extent in active and passive movements. Resisted movements should not be affected (although muscle weakness can accompany joint inflammation if wasting has occurred). Capsular restriction is in certain movements only, and the particular movements affected vary from one joint to another. Most importantly, these movements are restricted in a **fixed proportion** (not in a fixed amount). For example, the capsular pattern for the shoulder is a large restriction of lateral rotation, moderate restriction of abduction and a slight loss of medial rotation. A capsular problem which is not severe at the shoulder may only have a slight effect on lateral rotation to begin with, but as the disability develops the other movements will be affected in turn, abduction first and then medial rotation.

Restriction of passive movement in a non-capsular pattern suggests a lesion which does not involve the whole capsule, such as an individual ligament injury, a loose body or a lesion which lies outside the joint. If a ligament is torn and the resulting bleeding and inflammation cause the joint to swell the patient will have capsular signs of the injury. If the injury causes no swelling or if the swelling has settled by the time that the patient presents, you will find it by stress testing (passive stretching of individual ligaments, looking for pain and laxity, discussed above): there may be no capsular restriction. The examination of the ligaments will still be based on passive movements as befits a joint structure but it will be more focal, localised to the injured part alone.

It is important to recognise the capsular pattern when it is present so that restrictions in movement are properly interpreted. Without knowledge of the capsular pattern, it would be difficult to make any sense of certain examination findings. Capsular restriction is not a diagnosis in itself, but it narrows the field of investigation.

You will encounter capsular issues in minor injuries on every working day. To give one common example: the capsule of the knee usually imposes a position of about 10 degrees of flexion on the joint when it is inflamed and a patient with an injury in the knee joint may therefore limp on the ball of the foot, the so-called 'equinus' walking pattern. However, a patient with a torn meniscus may have a locked knee and may walk in equinus because there is a solid blockage to extension. It is therefore often the starting point of a knee examination to be confronted by a limping patient and to consider the features of a capsular presentation against those of a mechanical obstruction of a joint and to make a diagnosis.

Remember that not every injury within a joint will involve the whole joint capsule. In those cases you still use passive techniques but you stress targeted individual tissues, usually ligaments, to isolate the injury and decide upon its severity.

The capsular patterns for the main joints are given at the relevant places in those chapters.

Referred pain

Referred pain is pain which is felt in the wrong place. The fact that the brain can misinterpret the source of a pain is odd and it adds complication to your assessment of an injured patient. It can be even more of a hazard if the patient is seriously ill. Pain can be referred to less vital areas from major organs and life-threatening events can announce themselves with symptoms that could be mistaken for minor musculoskeletal ailments.

Pain referral is not random. The brain perceives pain on a regional basis but it can have difficulty distinguishing between the different tissues which are located in one region. The part of the body in which the brain locates the source of a pain signal is determined by which spinal vertebra receives sensory fibres from the injured part and where the **dermatome** for that vertebra lies. A dermatome is an area of skin which sends sensory fibres to one level of the spine. The same vertebral segment also receives sensory fibres from muscles in a defined area (which will not follow the outline of that segment's dermatome), the **myotome**, and from bone, the **sclerotome** (sclerotomes are less important in this discussion because pain from bone does not refer). The organs, or viscera, are also supplied with some sensory fibres and **visceral** pain can refer in the same way as muscle pain.

The apparent randomness of how sensory fibres are distributed to different tissues is explained by the fact that these arrangements occurred in the embryo and tissues which were close together at that stage of development were separated by subsequent growth. The dermatomes of the limbs are dispersed in a puzzling manner (Figs 5.1 and 5.2), whereas those on the trunk are closely related to their vertebral segment. In the embryo the limbs were no more than little buds at the top and bottom of the spine when the nerves developed. The dermatomes were 'stretched' by subsequent growth of the limbs but they retained their original relationships.

Cyriax's explanation for the referral of pain is that the brain is organised to receive sensory stimuli from the skin to a much greater extent than from the deeper tissues and it mistakenly attributes sensations to the skin that in fact come from the myotomes or viscera in a particular segment. Although the brain sometimes fails to indicate the source of deep tissue pain it can tell which segment the pain comes from and 'refers' it to the dermatome for that segment. Therefore, even if it is not clear where the pain is coming from, the possible sources are limited to the tissues which share that segment and that dermatome.

The dermatome for a given spinal segment can be a long way from organs and muscles supplied by the same segment. The heart sends fibres to T1 and T2 and so cardiac

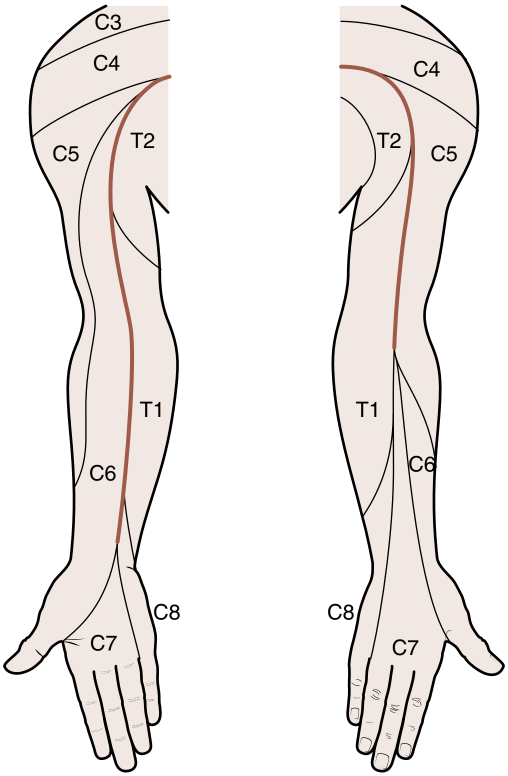


Fig 5.1 Dermatomes of the upper limb.

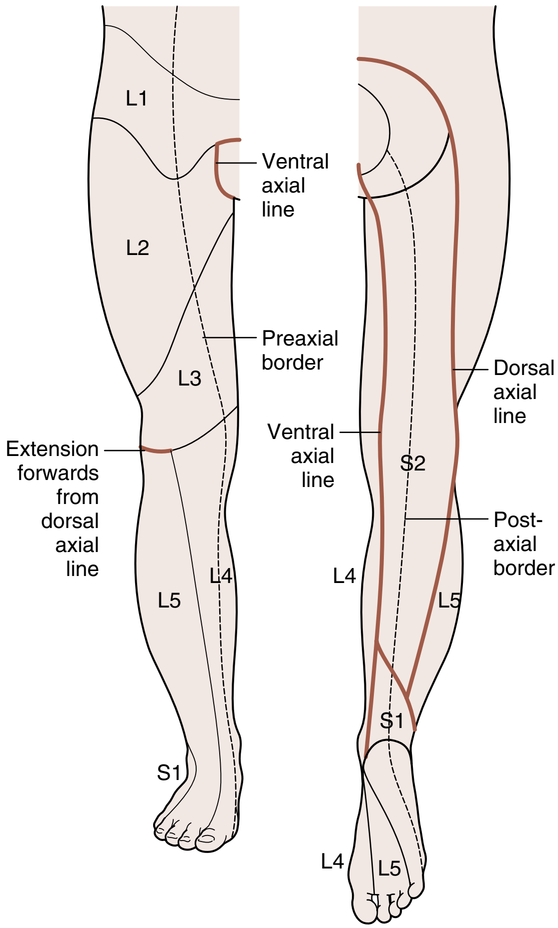


Fig 5.2 Dermatomes of the lower limb.

pain may be felt on the inner side of the arm. The diaphragm sends fibres to C3 and C4, with dermatomes at the neck and shoulder.

The interpretation of referred pain arising from an organ may be made easier by the fact that organ disease of any kind usually produces other signs and symptoms, as well as pain, which will clarify the issue. There may be features in the history or the patient's general appearance which suggest illness. You may examine the area and assess perfusion and nerve supply. Any applicable and available standard tools of assessment can be used: the vital signs, and perhaps urinalysis, blood analysis or electrocardiography. The failure to find a musculoskeletal injury at the painful place may warrant a medical review of the patient. A referral to a doctor will be more or less urgent depending on the patient's condition and the differential diagnosis.

The interpretation of pain referred from the spine itself is discussed in the chapter on the spine. The interpretation of pain referred by a musculoskeletal injury or disease is based upon the testing of the tissues which may be involved, those belonging to the myotome which shares a segment with the dermatome where the pain is felt. This has been discussed earlier in this chapter.

Referred pain has certain characteristics:

- Referral to a great distance from the site of the lesion can occur in the limbs because the dermatomes are long.
- Even when pain refers a long way, it will remain in the same dermatome.
- Although the pattern of referral is decided by the position of the dermatome, the patient can tell that the problem is not in the skin as the pain feels 'deep'.
- The more severe the pain, the greater the distance it refers.
- In most cases, pain refers distally to the lesion.
- Referred pain does not cross the midline of the body.
- The more proximal the lesion (ie, the closer to the trunk), and the deeper the source of pain, the more likely it is to refer: patients will localise injuries in the hand very well, whereas they are often vague about the source of shoulder pain.
- When pain is referred from an injury to muscle or joint, the quality of the pain does not vary according to the tissue which is injured; the injured part is found by testing the function of the possible sources in that segment.

In cases where it is not clear whether a pain is referred the tissues are tested at the painful site. If the pain is not increased (or decreased) and function is normal during testing then it is possible that the pain is referred. Test the tissues within that vertebral segment where the pain is felt. If that does not reveal the source, consider referral from a central organ. The neurological and vascular condition of the affected part must always be assessed.

Chapter | 6 |

The shoulder

CONTENTS

INTRODUCTION

Within the limits of its length and mobility the arm delivers the hand as the brain directs to the place, and in the position, which is best suited to its intention. Each part of the arm makes its own contribution to this activity. The shoulder is the fixed point, the junction between the limb and the trunk, from which these movements originate. The mobility of the shoulder determines the circumference of the hand's reach and the shoulder has such a range to the front that the hand is only limited by the length of the limb.

The shoulder is not a single joint: it is a group of joints whose common identity is based on its shared purpose. It connects the arm to the trunk and provides the bone, muscle and joint structures which position the hand. We can also combine rotation with extension to reach behind our backs. These are clumsier movements than those to the front but they still allow us to touch any part of our bodies with our hands.

The human shoulder is adapted for mobility compared to the same structure in quadruped mammals. The chest is wider and the bony girdle projects more to the side, throwing the limbs outwards from the trunk. The muscles are larger. There is also a bigger difference between the bones of upper and lower limb than is found in a four-legged creature. This is seen most clearly in the bones of the forearm.

The ways in which the shoulder tends to get injured suggest that these adaptations have only been partly successful. We are well designed to hold our hands comfortably to the front, where our eyes can see them. Much of our ordinary activity occurs in this position. Mobility far beyond this is present, but movement in the further reaches of the range, especially when the arm is held above shoulder level, causes stress and compression of delicate tissues between the bony surfaces of the humerus and the shoulder girdle. This can result in acute inflammation and degeneration and sudden rupture of important muscles. The main joint in the shoulder, the glenohumeral, is very shallow. This allows the freedom of movement which the humerus requires but the joint is unstable and it often dislocates.

Recurring patterns of shoulder pain and disability are therefore often linked to 'impingement' of muscles and other tissues between bone surfaces, rupture of the muscles of the rotator cuff and dislocation. Violent injuries will often cause fractures, most often of the proximal humerus and the clavicle, as well as dislocation of the glenohumeral and the acromioclavicular joints.

ANATOMY

The dynamic relationship of the arm to the trunk is established by a bony girdle, the main feature of which is mobility rather than stability. Such stability as the shoulder has is maintained by soft tissues, muscles, ligaments and capsular tissues.

The bones of the shoulder girdle are the **scapula**, the **clavicle** and the **humerus**. The scapula articulates with the chest wall at the back (the **scapulothoracic** joint), the clavicle laterally (the **acromioclavicular joint**) and the humerus, also laterally (the **glenohumeral joint**) (Fig. 6.1). In addition, the clavicle articulates at its medial end with the sternum (the **sternoclavicular joint**).

The scapula

The scapula is a triangular plate of cupped bone, with its concave anterior surface lying on the wall of the posterior thorax between the second and seventh ribs (Fig. 6.2).

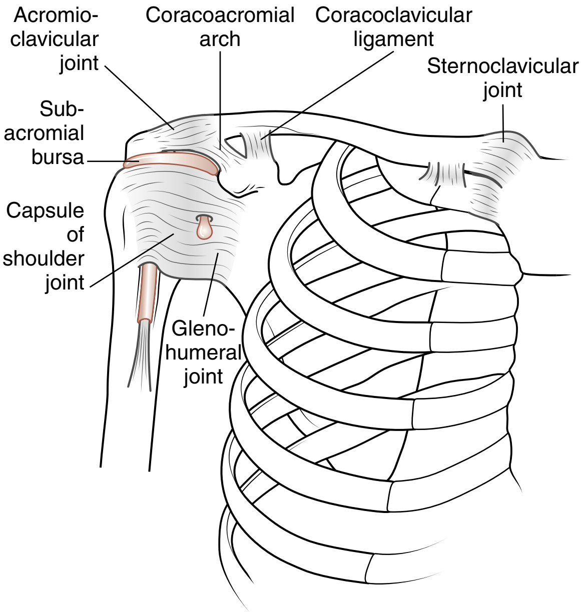


Fig 6.1 The joints of the shoulder region.

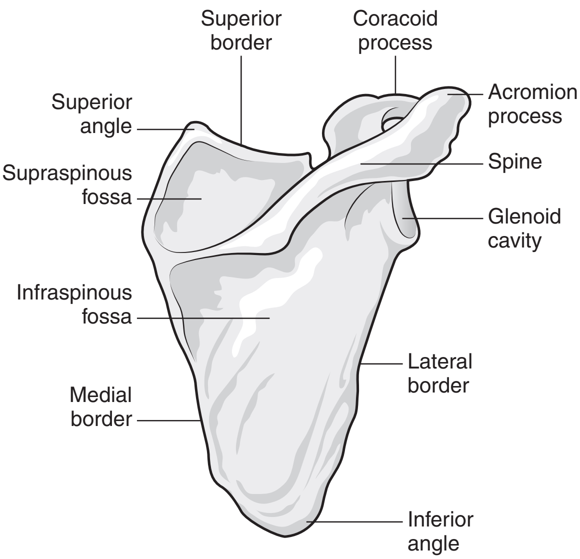


Fig 6.2 Posterior view of the right scapula.

It is attached to the trunk by muscles only (the term 'scapulothoracic joint' is used for this relationship, but there is no synovial joint between the ribs and shoulder blades). The apex of the triangle points downwards. A prominent bony ridge, called the **spine of the scapula** (a visible and palpable landmark on the upper back), crosses the dorsal surface of the scapula from high on its medial border to the superior, lateral corner of the bone, where it expands to become the **acromion process** (process means bony projection). This process articulates with the lateral end of the clavicle at the synovial acromioclavicular joint.

The dorsal surface of the scapula is divided by the spine into a small **supraspinous fossa** (meaning, the hollow above the spine), and a larger **infraspinous fossa** (hollow below the spine). The front surface of the scapula forms a single hollow called the **subscapular fossa**. Many of the muscles of the shoulder girdle are attached to these surfaces. At the **acromial angle** of the scapula, slightly inferior to the bony arch, two important structures are found. The **glenoid fossa** is the shallow socket which articulates with the head of the humerus to form the main shoulder joint. The **coracoid process** is a bony hook which points forwards and offers attachment for muscles and ligaments. It lies above the glenoid fossa, in the shelter of the acromion process. The bony arch over the shoulder is reinforced by the **coracoacromial ligament**, which crosses from the acromion to the coracoid process.

The scapula has a large repertoire of movements and contributes much to the mobility of the shoulder. It can be moved straight up and down, it can be adducted and abducted and it can rotate so that the glenoid fossa faces up or down. This allows the arm to move up and down and forwards and backwards as an integral unit. It also contributes internally to shoulder movement. Flexion and abduction are not simply glenohumeral movements. When the shoulder is abducted, a movement which has a total range of 180 degrees, the first 90 degrees occur at the glenohumeral joint, then the scapula rotates laterally and upwards, carrying the arm for another 60 degrees, and the glenohumeral joint takes over again for the final 30 degrees. It is important, when assessing shoulder movement, to observe the scapula.

The acromioclavicular joint

The acromioclavicular joint forms the bony arch which covers the shoulder joint proper. The joint has, in addition to its own capsule, the reinforcement of the **coracoclavicular ligament**, a two-part ligament made up of the **conoid** and **trapezoid** ligaments, which anchors the clavicle to the coracoid process of the scapula. No muscles cross this joint and its movement is passive only. The joint moves to allow movements of the scapula laterally and medially round the chest wall, up and down, and to allow scapular rotation when the shoulder is flexed.

The clavicle

The clavicle, seen from above, is a bone with curves following a long, flattened S-shape from the sternoclavicular joint, medially, to the acromioclavicular joint at its lateral end. It

is superficial and forms a distinctive dividing line between neck and chest. The clavicle braces the arm at the distance from the trunk which is necessary for it to have freedom of movement.

The sternoclavicular joint

The synovial sternoclavicular joint is the only point where the shoulder girdle is fixed to the trunk. Like the acromioclavicular joint, it has no capacity for active movement because no muscles cross it. It permits the clavicle to angle up and down, and forwards and backwards, and to rotate to a limited extent on its own axis (a movement which is initiated by rotation of the scapula).

The humerus

The humerus is the long bone of the upper arm (Fig. 6.3). At its proximal end its rounded head, tilting up and backwards, articulates with the glenoid fossa of the scapula to form the **glenohumeral** joint. The head is separated from the tubercles of the humerus by the anatomical neck. There are two **tubercles** (a tubercle is a rounded bony projection for the attachment of muscles), which crown the top of the shaft of the humerus. The **greater tubercle** is just lateral to the head of the humerus. The **lesser tubercle** is on the anterior aspect of the humerus under the anatomical neck. Between the tubercles is the **intertubercular sulcus** (sulcus means groove) also called the **bicipital groove**. The tendon of the long head of the biceps muscle lies in this groove. The humerus narrows below the tubercles, at the **surgical neck**, and continues as the **shaft** of the bone.

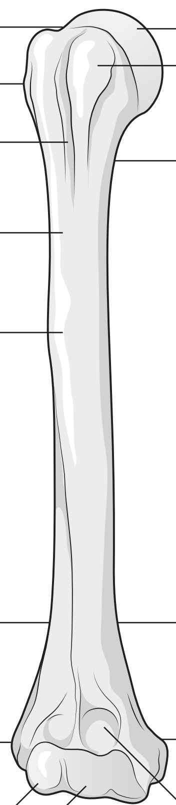


Fig 6.3 Anterior view of the right humerus.

The glenohumeral joint

The glenohumeral or shoulder joint is a shallow ball and socket joint. The glenoid fossa is slightly deepened by a fibrocartilaginous rim, the **glenoid labrum**. The capsule of the joint passes round the anatomical neck of the humerus and is strengthened in front by three ligaments: the **superior, middle** and **inferior glenohumeral ligaments**.

The capsule is also reinforced by the insertion around it, on the humerus, of the tendons of four scapular muscles, known collectively as the **rotator cuff** (Fig. 6.4). These muscles are **supraspinatus**, which abducts the shoulder, **infraspinatus** and **teres minor**, which are lateral rotators of the shoulder, and **subscapularis**, which medially rotates the shoulder. They can be remembered by the acronym **SITS**.

The tendons of the supraspinatus muscle and the long head of the biceps pass over the humerus and under the bony arch of the girdle. Between the tendons and the bone lies the **subacromial bursa**, to minimise friction. These soft tissues are vulnerable to various forms of degeneration, inflammation and trauma because they are liable to compression, or **impingement**, between two mobile bony surfaces. This can be aggravated if the subacromial space is narrowed for any reason (such as the formation of osteophytes) or if the soft tissues swell.

EXAMINATION (BOX 6.1)

Every shoulder examination where there is no history of direct trauma to the shoulder should begin with an assessment of neck movement (Box 6.2). If neck movement triggers or worsens the patient's pain, a problem at the neck is likely and must at least be excluded.

Neurovascular assessment of the arm when the shoulder is injured should pay specific attention to the possibility that the axillary and radial nerves are at risk. Assess sensation for the axillary nerve at the 'badge area' over the lateral deltoid, and for the radial nerve at the dorsal thumb web.

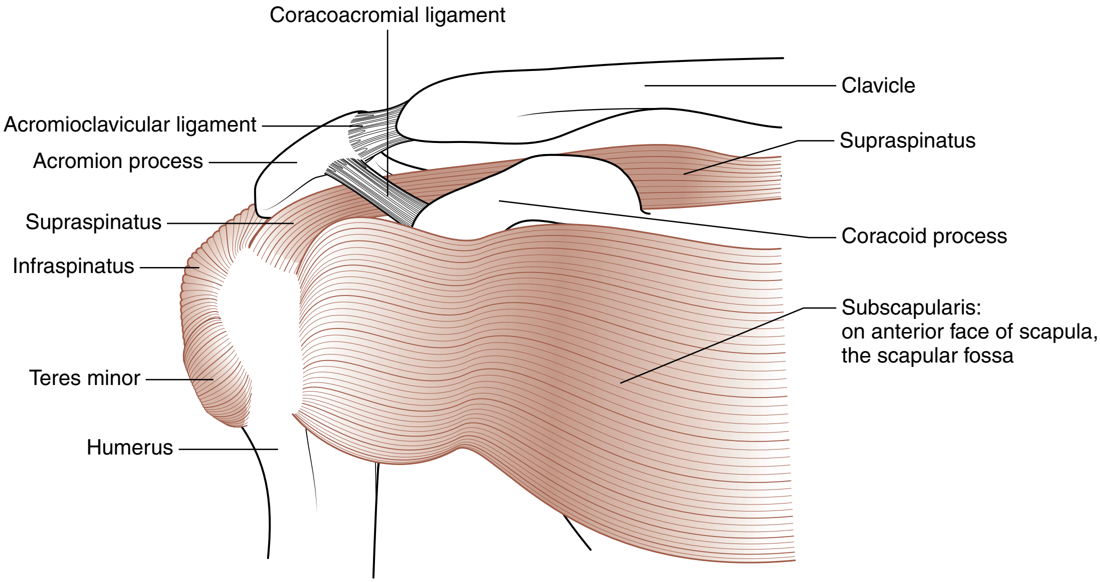


Fig 6.4 The rotator cuff of the glenohumeral joint.

> Box 6.1 **Shoulder movement statistics**
>
> - Capsular pattern: restriction in three movements, the largest being lateral rotation, the next abduction, and the least is medial rotation.
> - Joint positions: loose packed is 60° abduction and 30° horizontal adduction; close-packed position is in combined full abduction and external rotation, and in combined full extension and internal rotation.
> - Flexion 0–180°; endfeel firm; capsule stretching.
> - Extension 0–60°; endfeel firm; capsule stretching.
> - Abduction 0–180°; endfeel firm; capsule stretch.
> - External rotation 0–90°; endfeel firm; capsule stretch.
> - Internal rotation 0–70°; endfeel firm; capsule stretch.

Also make a resisted test of motor radial nerve function at the wrist (ask the patient to extend the wrist, place your hand on the back of the patient's hand and say 'don't let me straighten your wrist': if the wrist cannot extend, a 'dropped wrist', or if the wrist is weak, radial nerve palsy is possible secondary to a shoulder injury). The radial nerve test is performed a long way from the painful area and the patient will usually be able to comply.

Look

Assess the patient's posture, including the alignment of the spine and the position of the scapulae.

The muscles of the shoulder lie on top of the joint and swelling in the glenohumeral joint tends to be less prominent than at, for example, the knee. Inflamed structures are less likely to cause external redness. Violent injury at the top of the humerus can cause a large haematoma at the deltoid muscle.

Deformity is a common finding at the shoulder, when the clavicle is fractured and when the sternoclavicular, acromioclavicular or glenohumeral joints are dislocated. The lateral end of the clavicle rises when the acromioclavicular joint is injured. Occasionally a fracture at the lateral clavicle can produce a similar appearance. When there is an anterior dislocation of the humerus the outline of the shoulder, seen from the front, is flattened by the downward movement of the head of the humerus, so that the contour of the deltoid muscle appears to be lost. Check that the humerus has indeed dropped if the outline looks flat. Occasionally a fracture of the proximal humerus can produce a similar flattening with no dislocation. In that case the rounded head of the humerus will still be tucked under the acromioclavicular joint at the same level as on the other arm. Rupture of the biceps causes a large bunched swelling at the front of the elbow. Rarely, a torn supraspinatus muscle will show as a lump on top of the shoulder.

Observe the scapula for signs of winging. Winging occurs when the serratus anterior muscle no longer holds the medial edge of the scapula against the thorax, either because of failure of the motor nerve or injury to the muscle itself. The scapula will lift away from the chest, especially if the patient flexes the shoulder and pushes the palm against a wall.

Box 6.2 Shoulder examination

Ask the patient to expose both shoulders. Assess distal sensation and circulation:

- LOOK at the neck. Look and compare the shoulders, front, back and sides.
  – Is there asymmetry or wasting?
  – Is there redness, swelling bruise or deformity?
- FEEL the main landmarks. Feel the cervical spine.
  – Feel the anterior structures, the sternoclavicular joint, clavicle, acromioclavicular joint and coracoid process.
  – Feel the upper humerus, the greater and lesser tuberosities, the bicipital groove and the insertion of the supraspinatus.
  – Feel the scapula. Find its borders and the superficial ridge of its spine.
- MOVE
  – Assess ACTIVE NECK MOVEMENTS (see Figure 14.6). Do they cause the patient pain? Observe the scapula during shoulder flexion. It contributes 60° of the upper part of the movement by rotating and tilting the glenoid upwards.
  – If the patient feels pain at about 70° of abduction, gently encourage him to continue. If pain disappears in the upper half of the movement he may have an arc of pain, caused by supraspinatus impingement.
  – It is easiest to assess all active movements together, resisted together and passive together.
- Two SPECIAL TESTS

1. The DROP ARM TEST to show a rotator cuff tear.
   – Abduct the shoulder passively at 90°. Ask the patient to slowly lower the arm.
   – Pain and/or weakness is positive.
2. HORIZONTAL FLEXION to elicit pain from an acromioclavicular sprain. The patient abducts his shoulder to 90° then passes his arm across his chest, putting his hand on the opposite shoulder.

Feel

Palpate the joints, bones and muscles of the shoulder from the sternoclavicular joint on the anterior aspect to the spine at the back. The clavicle is superficial and continues laterally onto the acromion process of the scapula. The glenohumeral joint is accessible at the front, in the space between the arm and the ribs. A small, slightly sensitive lump may be felt in this space just above the glenoid. This is the coracoid process of the scapula. The head of the humerus is felt as a smooth dome tucked under the acromioclavicular joint at the front. The rotator cuff tendons insert into the greater tubercle of the humerus on the lateral shoulder. They can be made more prominent by extending and medially rotating the shoulder. Palpation of the muscle bellies of the rotator cuff is described below. Palpate the groove of the biceps on the anterior humerus. The subacromial bursa can be made more accessible by palpating the superior aspect of the humerus with the shoulder in extension.

Palpation of the muscles of the rotator cuff

It is important, in cases where there is shoulder pain and disability, to assess the function of the four muscles of the rotator cuff. Resisted tests for all of these muscles are illustrated, but some of these movements also use muscles which are not part of the cuff. You will find it useful to be able to find and assess the function of each muscle individually.

The spine of the scapula is the key landmark for three of the four muscles. The spine of the scapula is the superficial bony ridge which can be felt on ourselves by placing a hand on the opposite shoulder so that the fingers lie on the scapula. A diagonal ridge which travels from the medial scapula to the point of the shoulder is easily felt. When your finger follows it from the medial edge of the scapula the fingernail will face backwards for most of the journey. At the shoulder the nail will turn towards the ceiling. At this point you are on the acromion process. Trace that forward and begin to move medially. You will meet a raised lip of bone. This is the junction of scapula and clavicle, the acromioclavicular joint.

To palpate the supraspinatus, find the spine of the scapula and put a finger into the hollow which lies directly above it. Let your arm hang by your side. The supraspinatus initiates abduction of the shoulder, and you will feel a contraction of the muscle as soon as you lift your hand laterally away from your leg.

The infraspinatus and teres minor, which are examined as a single unit, lie together in the area below the spine of the scapula. Place your fingers there and move the shoulder into lateral rotation. The contraction of the muscles is easily felt.

Subscapularis is less accessible because it lies on the anterior surface of the scapula. Place your thumb into the posterior wall of the axilla, and your fingertips on the lower part of the scapula. When you medially rotate the shoulder you will feel the muscle glide under your thumb.

Move

The examination of the main shoulder movements is illustrated in Figures 6.5, 6.6, 6.7 and 6.8.

For active and resisted testing ask the patient to stand if that is possible. The shoulder is easier to assess if the arms are hanging freely. For passive testing patients are often seated, but relaxation and ease of handling the limb are

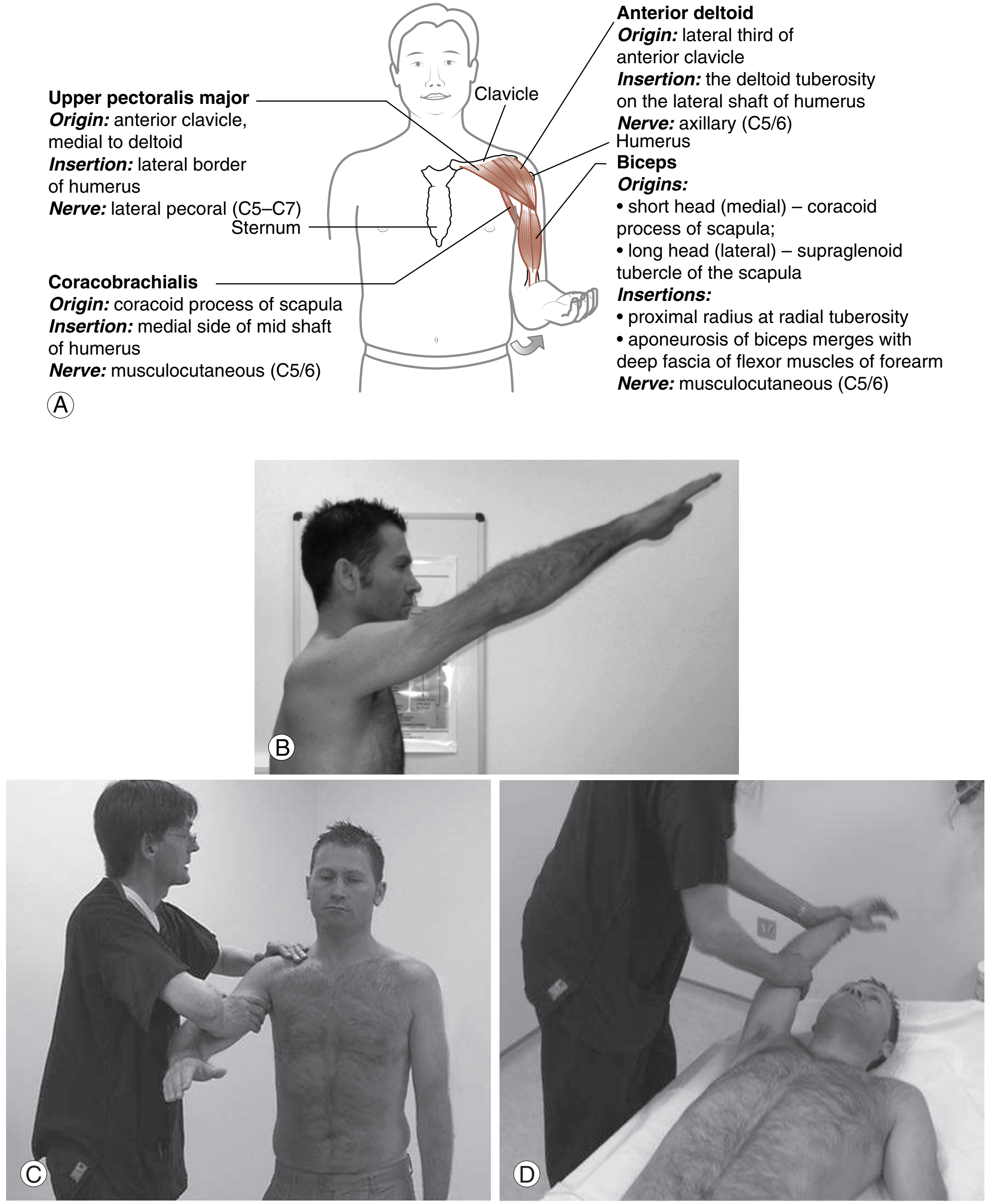


Fig 6.5 A, The flexors of the shoulder. B, Active flexion – observe scapular movement during the upper part of the range. C, Resisted flexion – test the movement in two parts, offering resistance above the elbow, and then below it to assess the biceps. D, Passive flexion.

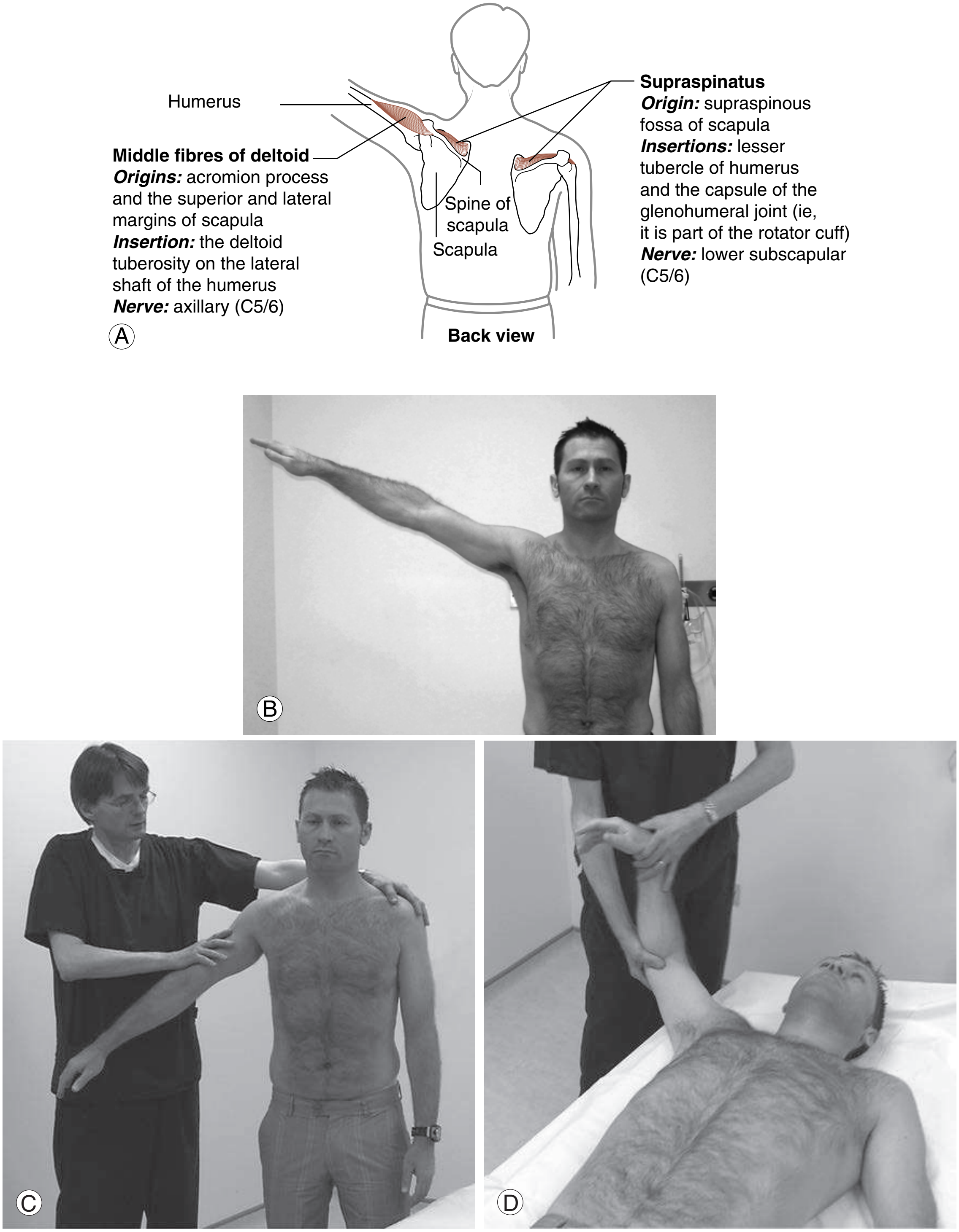


Fig 6.6 A, The abductors of the shoulder. B, Active abduction – observe scapular movement during upper part of the range. Is there an arc of pain? C, Resisted abduction. D, Passive abduction.

both improved if the patient lies down. It is very difficult to achieve passive shoulder examination with a standing patient.

You may wish to compare rotation in the other limb to establish the patient's normal range, but do this one arm at a time for lateral rotation. Otherwise the shoulders obstruct each other and the range is reduced on both sides.

Movement and the arc of pain

An **arc of pain** during abduction of the shoulder demonstrates the phenomenon called **impingement**. Impingement is the compression of a soft tissue between two hard surfaces. When the shoulder moves through abduction the greater tubercle of the humerus moves into contact with the acromion at about halfway through the movement and

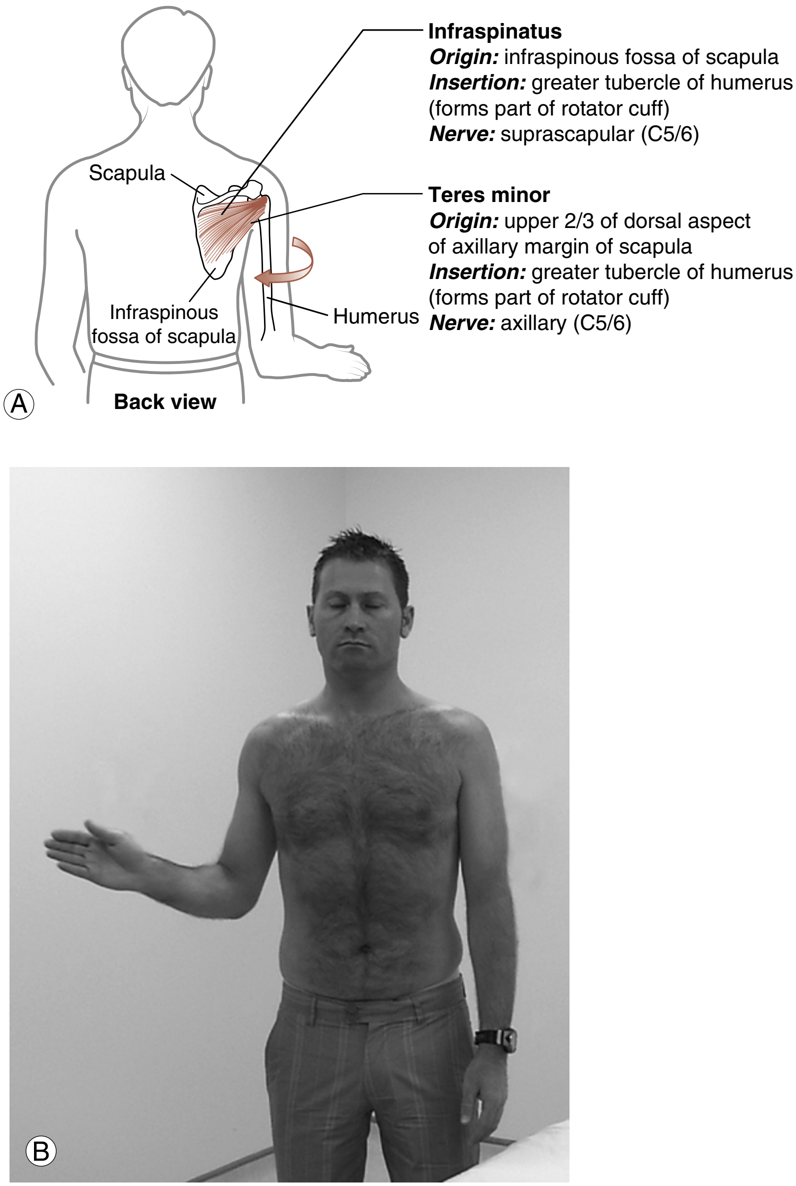


Fig 6.7 (A–C) The lateral rotators of the shoulder. B, Active lateral rotation – the patient flexes his elbow so that forearm rotation will not complicate the movement.

it moves away from it again in the upper third. It is during the contact phase that impingement of the supraspinatus can occur and the patient will have pain in this middle part of the movement only. An arc of pain, therefore, is a movement which is pain-free at the beginning and end but symptomatic somewhere in the mid range. In order to demonstrate that the patient has an arc of pain rather than, for example, a capsular problem such as a frozen shoulder, where pain would not improve at any later stage in the movement, it is necessary to take the patient past the painful zone to a point where movement becomes comfortable again. You must, in order to demonstrate an arc of pain, show that the patient has no pain at the beginning or end of the movement.

It is undesirable to demonstrate an arc of pain by asking the patient to push on through the pain on the way up and again on the journey down from full abduction. Three less unpleasant techniques, avoiding the painful area almost entirely, are available. Your choice from these three will depend on the precise cause of the patient's problem and you may have to try them all:

- If the impingement symptoms are caused by a muscle problem with no joint narrowing or other external factors, passive movement will probably eliminate the pain by reducing stress on the painful muscle. Ask the patient to abduct the arm actively and to stop if pain occurs. Once pain occurs ask the patient to lower the arm. You can now take the

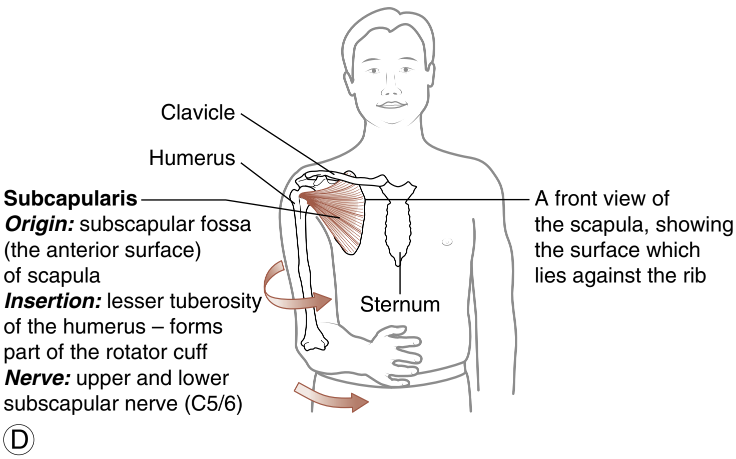


Fig 6.7,cont'd C, Resisted lateral rotation – keep the patient's elbow close to his body so that he does not use abduction instead of rotation. (D–G) The medial rotator of the shoulder.

Continued

Fig 6.7,cont'd E, Active medial rotation. F, Resisted medial rotation. G, Passive lateral rotation – with the shoulder in 90° abduction, medial rotation can be performed.

arm up to full abduction passively, without pain, and ask the patient to lower the arm actively. If the patient has a pain-free zone at the top of the range, before encountering discomfort on the way down, then you have demonstrated an arc. Once the patient feels pain ask him or her to stop and to return to full abduction. You can then lower the limb passively with no pain.

- Another technique is helpful if joint narrowing contributes to the problem and passive movement does not diminish the patient's pain. Abduction is usually tested with the patient's palm turned towards the leg in the starting position. If the patient has pain during the active and passive range bring the arm back to the starting position and ask the patient to rotate the shoulder and the forearm laterally so that the palm now faces outwards from the leg. This moves the bulging greater tubercle slightly backwards and gives a bigger space between the humerus and the acromion during abduction. This may let the patient reach full abduction without pain using active movement. You can then test the upper part of the movement without rotation, establish the arc of pain, rotate the arm again and bring the hand down in comfort.
- Another method of reducing impingement is to take the arm to the end position of abduction by a different route. The method of assessing the presence of an arc is the same as in the two techniques above but this time take the arm up to full abduction by asking the patient to take the hand across the front of the body and to carry it up like the hand of a clock to 12.

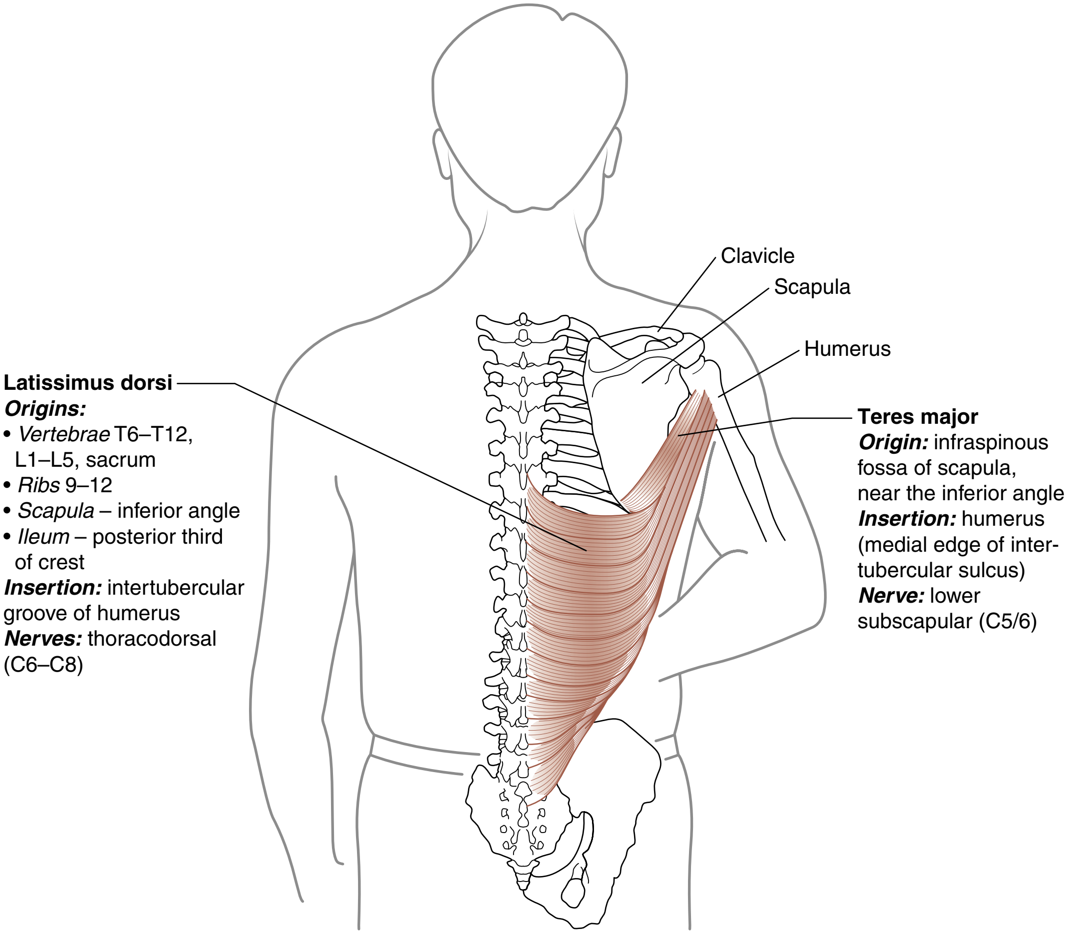


Fig 6.8 The extensors of the shoulder.

X-RAYS

The shoulder is a sequence of joints and is therefore complex in terms of imaging. Examine the patient carefully and choose the appropriate X-ray. The shoulder overlies a busy junction of spine and ribcage and it can be difficult to see superimposed parts on an image. It can also, on occasion, be difficult to be certain that the glenohumeral joint is not dislocated, especially when there is a fracture of the proximal humerus. The lack of spatial information in X-rays is well illustrated by an image of a head of the humerus which slightly overlaps the lip of the glenoid: is it in the joint or behind it? There are four standard categories of X-ray which you may request for injuries around the shoulder. They are listed here together with the common indications for requesting them in a minor injury unit (MIU):

- The clavicle is usually X-rayed after direct trauma or a fall on the hand with clinical evidence of fracture or dislocation of sternoclavicular or acromioclavicular joints. The clavicle is a rare exception among X-rays in that only one view is given. A comparative view of the two sternoclavicular joints is given when the possible diagnosis is dislocation of that joint.
- There are a considerable variety of shoulder views. They are requested after trauma if there is tenderness, deformity or other signs of fracture or dislocation, of the proximal humerus or the glenohumeral joint. They are also requested with no history of trauma but a severe onset of pain with reduced abduction suggesting a calcified supraspinatus tendon.
- The scapula is X-rayed after trauma with evidence of fracture, including tenderness, the loss of the

scapular range of shoulder movement and loss of scapular mobility. Scapula fractures are surprisingly uncommon.

- The shaft of the humerus, for injuries below the shoulder and above the elbow. There is a history of injury and evidence of fracture which usually includes a mobile, tender deformity. Shaft of humerus fractures are usually graphically mobile and unstable injuries: the muscles around the injury tend to pull the broken parts about. A fracture is unlikely if the patient has no signs of fracture beyond tenderness on one aspect of the bone.

Fig 6.9 The physis on a child's proximal humerus.
Source: From Manaster, B., May, D., Disler A., 2007. Musculoskeletal Imaging, fourth ed. Saunders.

There are a greater variety of X-ray views of the shoulder itself than any other limb joint. The main reasons for this are:

- it can be difficult to see if the glenohumeral joint is dislocated in a posterior direction
- to show if the joint is dislocated when the proximal humerus is fractured
- small fractures from the proximal humerus or the glenoid can be hard to see.

Familiarise yourself with the standard views which are done in your department and consult your radiographers when you have difficult cases.

In children the physis at the proximal humerus has an inverted 'V' shape (Fig. 6.9) and there are ossification areas at the acromion and the tip of the coracoid: these can be mistaken for fractures.

The anteroposterior (AP) view (Fig. 6.10)

Seen from the front with the humerus in slight lateral rotation, the appearance of the humerus at the glenohumeral joint is described as a 'walking stick'. This refers to the asymmetrical tilt of the rounded half sphere of the head of the humerus towards the glenoid. When the humerus dislocates in a posterior direction it rotates internally and this removes the asymmetrical angle of the head: instead it looks like the head of a match or a '**light bulb**' (Fig. 6.11). The light bulb sign on an AP view can be present without dislocation if the patient's shoulder was internally rotated during the exposure.

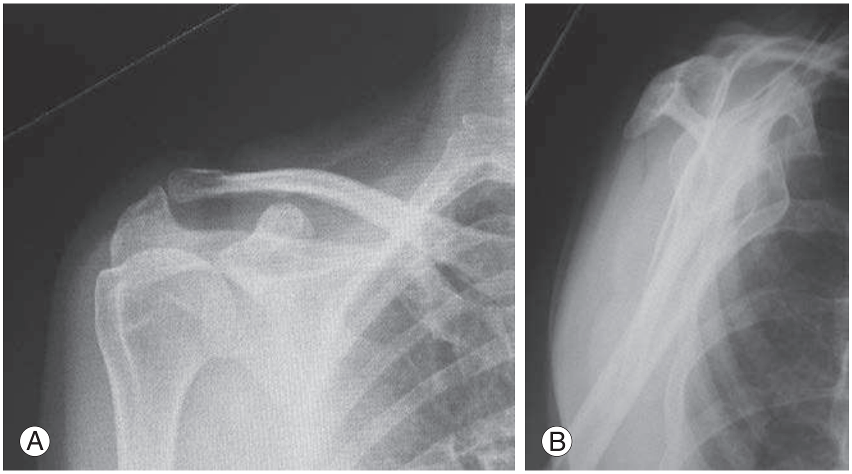


Fig 6.10 Normal AP view (A) and Y view (B) of the shoulder.

Fig 6.11 A 'light bulb' head of the humerus, showing a posterior dislocation.

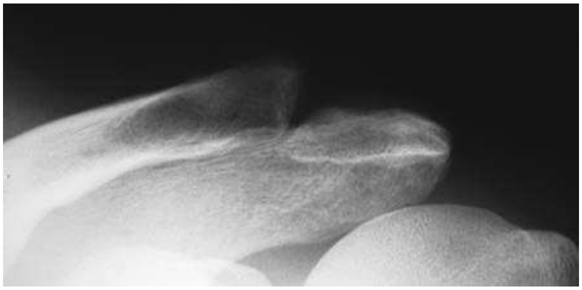


Fig 6.12 An acromioclavicular tear.
Source: From Raby, N., Berman, L., Morley, S., de Lacey, G., 2005. Accident and Emergency Radiology: A Survival Guide, second ed. Saunders.

Always correlate X-ray appearances with clinical findings. The AP view shows the lower margin of the clavicle and acromion as a straight line if no acromioclavicular (AC) dislocation is present. If AC dislocation is present the clavicle rises (Fig. 6.12).

Other shoulder views:

- The **axial** view (Fig. 6.13) is exposed through the axilla with the shoulder abducted and shows the head of the humerus sitting on the glenoid like a **golf ball on a tee** if the joint is properly aligned. This is an excellent view to demonstrate the absence of a posterior dislocation.
- The **Y** view (Fig. 6.14) is a lateral image of the scapula, looking into the glenoid. There is no 'lateral shoulder' view available because overlap of the joint on the chest makes interpretation impossible. The Y view is so-called because, in a normal X-ray, with no dislocation present, the head of the humerus sits symmetrically over the glenoid at the junction point of a Y shape (note that in this position the 'light bulb' appearance of the head of the humerus is normal). The three limbs of the Y are downwards along the margin of the scapula; up and forwards to the coracoid; up and backwards along the spine of the scapula to the acromion.
- The **apical oblique** (Fig. 6.14) is a modification of the axial view, obtained without lifting the arm, which demonstrates glenohumeral alignment.

Fig 6.13 The axial view.
Source: From Raby, N., Berman, L., Morley, S., de Lacey, G., 2005. Accident and Emergency Radiology: A Survival Guide, second ed. Saunders.

Fig 6.14 The oblique axial view.
Source: From Raby, N., Berman, L., Morley, S., de Lacey, G., 2005. Accident and Emergency Radiology: A Survival Guide, second ed. Saunders.

Fig 6.15 Clavicle fracture.
Source: From Taylor, J., Hughes, T., Resnick, D., 2010. Skeletal Imaging: Atlas of the Spine and Extremities, second ed. Saunders.

On the rare occasions when you suspect a fracture of the scapula request a scapula rather than shoulder X-ray. Similarly a clavicle view is specific. It is difficult to see the sternoclavicular joint on X-ray because of overlap with the cervical spine and ribs but an anterior dislocation is superficial and easy to diagnose. An AC joint dislocation is also easy to see clinically, but exclude a lateral clavicle fracture by requesting a clavicle X-ray (Fig. 6.15). There are specific X-rays for grading an AC tear (the patient holds a heavy weight in both hands, both shoulders are X-rayed to show the increased gap on the affected side). There is no indication for those views in the minor injury setting. For the purposes of immediate management, you will be able to evaluate the severity of the injury very well from the clinical presentation.

INJURIES

The shoulder can be injured by violent trauma and a variety of bone, joint, ligament and muscle injuries are common. The shoulder is also disposed, by its anatomy, the effects of its large range of movement and the often heavy demands made upon it, to suffer inflammation and degeneration. It is also, like the hip, a common site for referral of nerve root pain from the spine and pain from the organs.

Violent trauma most commonly affects the shoulder when there has been a direct blow to the joint, or when force is transmitted by a fall on the extended hand or the flexed elbow. The patient will have a clear history of injury. There may be deformity, pain and disability. Vital structures in the arm, and occasionally in the neck, may be compromised.

Young children are not prone to dislocations of the shoulder but adolescents move towards adult patterns of injury, especially when they are involved in sport. The commonest shoulder fractures, of the proximal humerus and clavicle, occur in children. Children are also prone to overuse injuries around the shoulder if they play throwing and racquet sports. Upper limb problems of this kind are more common in the USA than the UK because of the prevalence of baseball, but cricket, tennis and badminton create similar stresses on the shoulder. Swimming also involves stressful overhead movements.

The shoulder is prone to stiffness if it is immobilised and any prolonged spell in a sling should be followed by an assessment of the need for physiotherapy. Elderly patients are particularly vulnerable.

Sternoclavicular dislocation

Sternoclavicular dislocation results from injury to the ligaments joining the medial end of the clavicle to the sternum and the first rib, causing displacement of the clavicle. It is usually caused by a direct blow or a fall on the outstretched hand.

There will be asymmetry of the sternoclavicular joints, with a small new bulge to mark the displacement, and tenderness at the site.

Dislocation is normally anterior and uncomplicated, but a posterior displacement can threaten the airway and circulation. A fracture should be excluded and the dislocation is treated as a ligament injury. The injury is not reduced. It will not remain in joint. There are too many vital structures in the area for surgery to be undertaken lightly. Advise the patient that the swelling will be permanent but that normal use of the arm should be regained.

Fracture of the clavicle

The clavicle can be fractured after a direct blow or a fall on the outstretched hand. There will be pain, tenderness and swelling; frequently, there will also be deformity with crepitus and a palpable step or angulation at the site of fracture (usually at the outer third of the bone). Fracture at the lateral part of the bone can involve the acromioclavicular joint. Children suffer a greenstick pattern of clavicle fracture.

The clavicle is very superficial: ensure that the skin is intact at the site. It is surprisingly uncommon to see an open clavicle fracture in an MIU.

There can be complications, neurovascular injury and pneumothorax. Torticollis can indicate a simultaneous rotational injury to the cervical spine. A violent impact to the clavicle can also fracture upper ribs.

Support the injury in a broad arm sling and advise the patient to expect a new swelling at the site when callus begins to form. Follow the patient up according to your local policy. Surgery is occasionally performed on a fractured clavicle but it is usually left to heal conservatively. Children heal in about 3 weeks and adults in 6 weeks.

Acromioclavicular dislocation

A sprain at the acromioclavicular joint is common, but complete dislocation is much less so. Rupture of the acromioclavicular ligament and, in some cases, the trapezoid and conoid ligaments (sometimes accompanied by capsule and muscle tear and fracture), which stabilise the outer end of the shoulder girdle, cause separation of the clavicle and scapula.

A blow to the point of the shoulder or a fall onto the shoulder, the point of the elbow or the outstretched hand, are the usual mechanisms of injury.

The patient will have pain and tenderness on top of the shoulder with loss of movement, active and passive. The separated distal end of the clavicle will probably bulge upwards and will not move backwards with the acromion when the scapula is adducted. The larger and more widespread the tear, the higher the lateral end of the clavicle rises above the acromion.

X-rays of the two shoulders with the patient holding weights in both hands will demonstrate the gap caused by the sprain. This permits grading of the injury. These X-rays are not required in an MIU and orthopaedic doctors will also have other options, including magnetic resonance imaging, but you should request a standard clavicle X-ray to exclude a fracture at the lateral end of the bone. Inspect the ribs and lung markings on the image. Fractures of the acromion process are unusual.

The acromion and clavicle will not resume their former positions after a large tear and the patient will retain the tell-tale upwards bulge of the lateral clavicle. This can disrupt the delicate subacromial environment and arthritic degeneration of the shoulder can follow. Larger tears will normally receive orthopaedic attention and surgery is sometimes considered for severe injuries. However, mobilisation and physiotherapy are the usual treatments.

Anterior shoulder dislocation

Anterior shoulder dislocation is a fairly common injury. A history of previous episodes is also common. Displacement of the head of the humerus occurs, forward, down and medially from the glenoid cavity of the scapula.

The patient usually falls on the outstretched hand with external rotation of the arm. There may have been a violent pull on the arm, outwards and back, or a blow to the back of the arm which forces the head of the humerus forward. Previous dislocation predisposes many patients to recurrence with only a slight injury: a patient who has had regular recurrences can wake up in the morning with a dislocated shoulder.

The patient presents with an internally rotated arm held against the body by the other hand. There is a hollow under the acromion, a vacuum caused by the absence of the head of the humerus. The lateral shoulder looks flattened seen from the front: the widest part of an uninjured shoulder is at the level of the deltoid muscle but the acromion is the widest part when dislocation is present and it has a squared-off, angular appearance quite unlike the normal shoulder.

There is a risk of injury to the axillary nerve and artery. Assess the patient's sensation at the 'badge area' on the lateral deltoid and assess distal perfusion. It is also routine with all shoulder injuries to assess the radial nerve by checking sensation on the dorsal web of the thumb and resisted extension of the wrist. Displacement of the head of the humerus can tear the anterior and inferior aspect of the glenoid labrum, a **Bankart lesion**, and also cause a depressed fracture on the head of the humerus, a **Hill-Sachs** lesion.

Request an X-ray of the shoulder to demonstrate the dislocation and rule out fracture.

There are a variety of methods for reduction of dislocation, among which Milch and Kocher's are common. These techniques are described in various modifications in different places. Common themes are the use of traction to overcome muscle spasm and lateral rotation to lift the head of the humerus back into the glenoid. There is no method which works for everyone: it is not clear whether the significant factor in this variety of outcome is the patient or the process but it is not a procedure which responds well to haste or force. The chief obstacle to reduction is muscle spasm and severe pain can mean that the patient receives a combination of strong analgesia and sedation before the procedure. Milch involves traction on the humerus, lifting the arm into abduction at about 90 degrees and gentle lateral rotation of the shoulder and then guiding the head of the humerus back into the glenoid with a hand at the joint. This should overcome spasm with relatively little pain. Kocher's requires flexion of the elbow to 90 degrees, lateral rotation of the shoulder followed by adduction of the arm. Complications of reduction include spiral fracture at the head or shaft of the humerus caused by forcing lateral rotation on a blocked head (and it does not require much force), tears of rotator cuff and joint structures and neurovascular injuries. Avoid sudden or forcing movements during reduction and desist when you encounter obstruction, especially in rotation. It is sensible to learn these procedures 'in-house' but you should not undertake them except as part of a well-supervised training plan.

Occasionally a patient will present who has had many dislocations and who is normally able to reduce their own displacements. Repeated injury slackens the joint so that it

dislocates more easily but compensates slightly by making treatment easier. If, on this occasion, the patient is having trouble reducing it, and nothing violent has occurred to make the diagnosis doubtful, you may be able to achieve the reduction by a gentle and straightforward manoeuvre. There are two which are commonly useful:

- Before deciding on a technique, ask the patient how he or she normally reduces the injury. The technique may simply require an extra pair of hands to be successful. Also ask the patient if he or she has any idea why self-reduction has failed on this occasion. Light touch techniques will only work if the reduction is uncomplicated.
- Flex the elbow to 90 degrees, adduct the upper arm to the lateral chest and laterally rotate the shoulder. The head of the humerus will be seen popping back into the joint. Do this gently and stop if the head of the humerus feels blocked. Remember always the risk of spiral fracture when imposing rotation on the humerus.
- Ask the patient to lie prone on a trolley with the affected arm hanging down towards the floor. Apply and maintain firm but moderate traction downwards on the wrist and massage the inferior angle of the scapula at the same time. This technique is gentle but it can take time.

Assess neurovascular supply after reduction, and immobilise the injury in a firm support. Request a second X-ray to demonstrate the reduction. Refer the patient for orthopaedic clinic follow-up.

Posterior shoulder dislocation

Posterior shoulder dislocations are much less common than anterior dislocations but, in those affected, a history of recurrence is common. The head of the humerus rotates medially so that it is facing backwards and it slips behind the glenoid. The upper arm is therefore fixed in medial rotation.

A fall on an outstretched arm is often the cause of the injury, especially if the shoulder is flexed to 90 degrees and the elbow extended. Other mechanisms include a direct frontal blow to an internally rotated arm or a direct blow to a flexed elbow, which drive the humerus back. This injury may be present in patients with shoulder symptoms after electric shock, epileptic fit and with certain neurological conditions (obstetrical and Erb's palsies).

The injury can be missed. Anterior dislocations are easy to see on X-ray because the humerus descends below the glenoid. Posterior displacements do not have this feature. The head of the humerus remains at the same height and the decision that it has displaced is harder to make. General pain, local tenderness and loss of shoulder movement are seen, sometimes with deformity. The displaced head of the humerus may be seen at the back (although it is largely covered and made inaccessible by the scapula) below the acromion.

Traction tends to be the common theme for reductions of posterior dislocations.

Complications include neurovascular injury, rotator cuff injury and recurrence.

Fracture of the proximal humerus

The proximal humerus can break with a direct blow, a fall on the side of the shoulder or a fall on the outstretched hand or point of flexed elbow. The injury is classified according to the number of broken fragments seen on X-ray: a single fracture line causes a 'two part' fracture.

The presentation includes pain, loss of movement, local tenderness and, often, deformity, swelling and bruising.

Complications may include neurovascular compromise of the arm and rotator cuff injury. Glenohumeral dislocation can accompany severe comminuted fractures and surgery is sometimes needed.

Fractures across the surgical neck of the humerus are usually managed in a collar and cuff sling, supporting the wrist and letting the elbow hang free. The weight of the free elbow will help to overcome spasm and align the fracture.

Rupture of the rotator cuff

Two patterns of injury are seen in the rotator cuff, the first more common:

- an older, manual worker who is predisposed by degeneration of the joint and who suffers an acute, possibly slight, injury
- a violent acute episode, often in a young athlete.

A tear occurs at the tendinous insertion around the greater tubercle of the lateral head of the humerus of one or more of the muscles which support the shoulder joint. Typically, the site of a small tear will be the supraspinatus, with larger tears also including the infraspinatus, teres minor and subscapularis in that order.

The mechanism may be a fall on the outstretched hand or direct violence. Contraction of any muscle of the cuff, against resistance, can tear that muscle.

Presentations are variable. A complete tear may not be painful. There will be disability. There will be a loss of active abduction, especially at the start of range and, perhaps, local tenderness. The patient will fail the 'drop arm' test, lowering the arm from full abduction and losing active control and letting it fall at 90 degrees.

Small tears are treated conservatively, but large ones may require surgical repair. Complications include poor recovery, even with surgery, for larger lesions. The tendon tears close to the humerus and there is little anchorage

for a repair. If the tendon has torn at the end of a process of degeneration it offers poor, fragile material for a repair.

Supraspinatus tendinitis

Supraspinatus tendinitis is primarily an overuse injury of an abductor muscle which is compressed between the acromion and the lateral head of the humerus when the arm is lifted above shoulder height.

The patient has pain, with tenderness near the insertion of the muscle, and a **painful arc** during abduction (this means that the movement begins and ends without pain but the patient has pain during the movement, usually at about the range of 80 to 120 degrees of abduction). Pain caused by compression of a soft tissue between two hard surfaces is called 'impingement'. If the problem is purely one of tendinitis the patient will have pain on resisted, but not passive, abduction.

The clinical picture can be more complicated than that of a simple muscle injury if, for example, the patient has had an old acromioclavicular joint injury and the subacromial joint space is decreased or if the subacromial bursa is swollen. The injury will now have features of both muscle and joint injury and the patient may have an arc of pain which limits passive movements.

It is important, if you believe that a patient has an arc of pain, that you can demonstrate that abduction becomes pain-free in its upper zone. Otherwise, given that the capsular pattern for the shoulder includes limitation of abduction, the problem could have another cause. It is also important to do this without causing the patient excessive pain. This has been discussed in the section on examination of the shoulder.

This injury can be of a chronically inflamed type. The pain may be associated with a tendon tear and may require surgery.

The problem may settle with rest. It often needs physiotherapy and responds well to treatment. The general practitioner may give a steroid injection.

Acute calcific tendinitis

Degeneration of the supraspinatus tendon, especially in those over 30 years of age, can make it prone to inflammation when overused, and this can be followed by the depositing of calcium salts in the tendon.

There is a sudden onset of severe pain with tenderness in the upper anterior and lateral shoulder, sleeplessness, inability to work, guarding of the arm and reluctance to have it examined. The calcium deposit will be visible on X-ray.

Treatments include rest and analgesia, steroid injection, aspiration of the deposit in some cases and physiotherapy. In cases which do not settle, surgical treatment, curettage of the deposit, may be needed.

Subacromial bursitis

Inflammation of the subacromial bursa can be caused by overuse or impingement, and trauma to the shoulder may cause bleeding in the bursa. Other shoulder problems such as a supraspinatus tear or impingement may also be present.

There is a fairly quick onset, pain that disturbs sleep and prevents lying on the affected side, a sensation of having a 'heavy arm', referral of pain to the humeral deltoid insertion and a painful arc between 80 and 120 degrees of active and passive abduction. There may be tenderness and a boggy feeling at the head of the humerus when the top of the shoulder is palpated in extension.

Treatment is rest followed by gradual mobilisation, which may settle an acute form. A more difficult chronic form may respond to a steroid injection. Prolonged inflammation caused by adhesions in the bursa may result.

Winging of the scapula

The scapula is held flat against the thoracic wall by a muscle called the serratus anterior, which is attached to the medial edge of the bone on the anterior surface and then passes laterally and forward by separate strands to join the ribs. If this muscle is torn or paralysed by injury to the long thoracic nerve the inner border of the scapula will lift away from the back, a condition known as 'winging scapula'. Winging tends to be elicited if the patient flexes the shoulders to 90 degrees and presses the palms against a wall. This condition may require orthopaedic or neurological assessment.

Referred pain to the shoulder

A patient presenting with a shoulder problem, but no history of injury, will usually complain of pain. Where there is no clear history of injury, do not assume an injury to be present. Three other categories of problem must be eliminated:

- Disease affecting the joint. Sepsis is the most urgent condition in this category. Frozen shoulder is a more chronic joint condition characterised by increasing pain and progressive loss of movement. Restriction will be in the capsular pattern for the shoulder, a large loss of lateral rotation, a medium loss of abduction and a small loss of medial rotation and the restrictions will be as great in passive movement as active, with resisted movements strong.
- Illness at another site, referring pain to the shoulder. The list is long and includes life-threatening events. Some of these are myocardial infarct, pneumothorax, pneumonia, tumour,

aneurysm, gallbladder infection, ruptured spleen and ectopic pregnancy.
- The cervical spine can refer pain to the shoulder and should always be assessed as part of a basic shoulder examination.

Look for the unwell patient with a high temperature or abnormal vital signs. Musculoskeletal injuries cause pain and loss of function in the structure affected. Other symptoms such as fever, malaise, weight loss, breathlessness, cough, anorexia, vomiting and bladder or bowel changes should not appear in the history of an injury. Take a careful past medical history and assess it for possible connections to the presenting complaint. Examine the patient's account of the complaint, its onset, duration and pattern of pain: is it consistent with an injury? Go back to these questions if the shoulder examination, including an assessment of the neck, does not reveal an injury. If no answer is obtained seek a medical opinion.

Chapter 7

The elbow

CONTENTS

INTRODUCTION

The elbow is a synovial hinge joint. Its contribution to the work of the arm is humdrum: wherever the hand has gone roving, engaging with the world on behalf of the brain, the elbow brings it home to the prosaic routines of self-care; feeding, cleaning, dressing, grooming: we need elbows for everything that we do to ourselves with our hands (Box 7.1). In fact we need them for any task which is not performed at full arm's length. You will occasionally see patients who have had the misfortune to fracture both elbows: even the young and healthy may find themselves admitted to hospital for nursing care because they can no longer deliver to themselves the smallest personal attentions.

The elbow has structural similarities to the knee but, perhaps surprisingly in view of the greater mobility of the arm compared with the leg, the junction of humerus and ulna is simpler and the less mobile of the two: the radius only moves freely because it can depend upon the foundation of the ulna and a firm elbow.

The elbow is stable and its main structures are relatively simple. However, it is the host for structures, bone and muscle, whose work is done below the elbow: these unruly guests may not be part of the joint proper but they cause much of the mischief which occurs there. The head of the radius is the most common site for adult fractures around the elbow. The muscles of the wrist and forearm which cross the joint are prone to inflammation at their attachment points on the humerus and can cause obstinate problems there.

The elbow has a complicated pattern of growth and its patterns of injury are somewhat different in children. X-rays can be difficult to interpret for non-specialists.

ANATOMY

The elbow lies in close relation to the proximal radioulnar joint. This will be discussed with the wrist and hand. There are three bones at the elbow, the distal **humerus**, the head of the **radius** and the proximal end of the **ulna** (Figs 7.1 and 7.2).

The humerus

The humerus, seen from the front, has a triangular appearance at its distal end as the shaft broadens and becomes flattened. The medial corner of the triangle, the widest point of the inner elbow, is the **medial epicondyle**. At the outer side is the smaller **lateral epicondyle**. The lateral epicondyle is less prominent than the medial, partly because it is smaller and partly because the muscles which cross the elbow on the lateral side attach not only to the epicondyle but also to the shaft of the humerus immediately above it, clothing the outline of the epicondyle on that side with flesh. The borders of the triangle of the distal humerus, which pass from its shaft to the epicondyles, are called the **lateral** and **medial supracondylar ridges**. Seen from the side, the distal articular surface of the humerus has a bulbous appearance and a forward curve which reinforces flexion, the cardinal movement of the elbow. The articular design of the distal humerus is the most elaborate of any of the long bones. This is because the humerus is the only long bone which simultaneously articulates with two other long bones. The lateral part of the articular surface is the **capitellum** (also called the **capitulum**), a rounded prominence for articulation with the head of the radius. The medial articulation, the **trochlea**, resembles a horse's saddle, with a waist between two prominences, of which the medial is larger. This inequality

Box 7.1 Elbow statistics

- Capsular pattern: greater limitation of flexion than extension.
- Joint positions: loose packed is 70–90° flexion with 10° supination; close packed is full extension with supination.
- Flexion 0–150° with tissue approximation endfeel as muscle meets muscle. If the patient is thin the endfeel may be hard as the coronoid process enters the fossa. Extension has a hard, bony endfeel as the olecranon enters its fossa. There can be 10° of hyperextension at the joint.

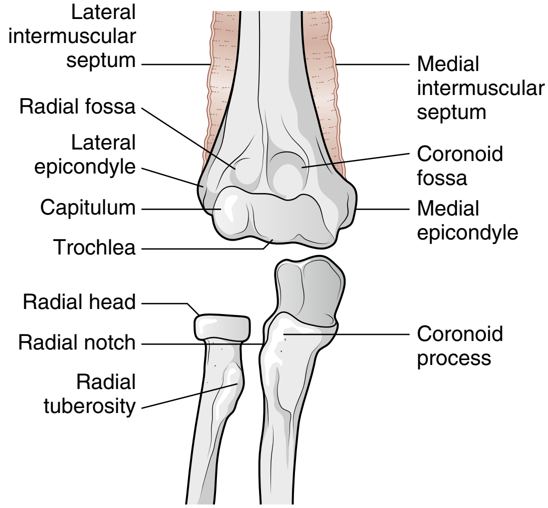


Fig 7.1 Anterior view of the elbow bones.

causes the ulna to sit at a valgus angle of 10–15 degrees (the **carrying angle**), slightly more for women, when the arm is straight. There are two hollows on the front surface of the humerus, just above the two articulations. Above the capitellum is the **radial fossa**, and above the trochlea is the **coronoid fossa**. The head of the radius and the coronoid process of the ulna use these hollows when the elbow is fully flexed. On the back of the humerus, at the same level, is a larger single hollow, the **olecranon fossa**, which accommodates the olecranon process of the ulna so that the arm can achieve a straight line when the elbow is extended.

The radius

The radius is the lateral of the two long bones of the forearm. Its head, sitting on top of a slender neck, resembles the head of a nail, and it has a concavity on its top surface for

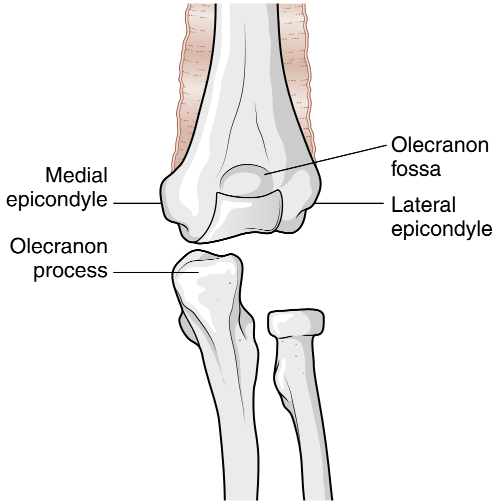


Fig 7.2 Posterior view of the elbow bones.

articulation with the capitellum. The radius is bound to the ulna proximally by an **annular ligament** (meaning ring), a loop which keeps it close to the ulna while leaving it free to rotate axially.

The ulna

The ulna is the medial long bone of the forearm. At its proximal end, the bone is expanded with an articular surface which is slightly like a cupped hand with the thumb held in front of the palm. There are two processes in this area. The **olecranon process** is like the clawed fingers of the hand. Its posterior part forms the point of the elbow. The process sits in the olecranon fossa when the elbow is extended. The front of the olecranon, its articular surface, is concave, the **trochlear notch**, and it encloses the trochlea to create the elbow joint. At the base of the trochlear notch in front is a projection, the 'thumb' of the cupped hand, called the **coronoid process**. The coronoid process stabilises the trochlea in the same way as the thumb stabilises a ball held in the hand. It sits in the coronoid fossa when the elbow is flexed. On the lateral aspect of the coronoid process is a small hollow, the **radial notch**, which articulates with the radial head.

The ulnar collateral ligament

The ulnar collateral ligament of the elbow reinforces the joint capsule on the medial side and stabilises the joint against valgus stress and, with the radial collateral ligament, limits the range of abduction, adduction and rotation (Fig. 7.3). It also helps to stabilise the relationship between humerus and ulna. The ligament spreads out in a triangular shape

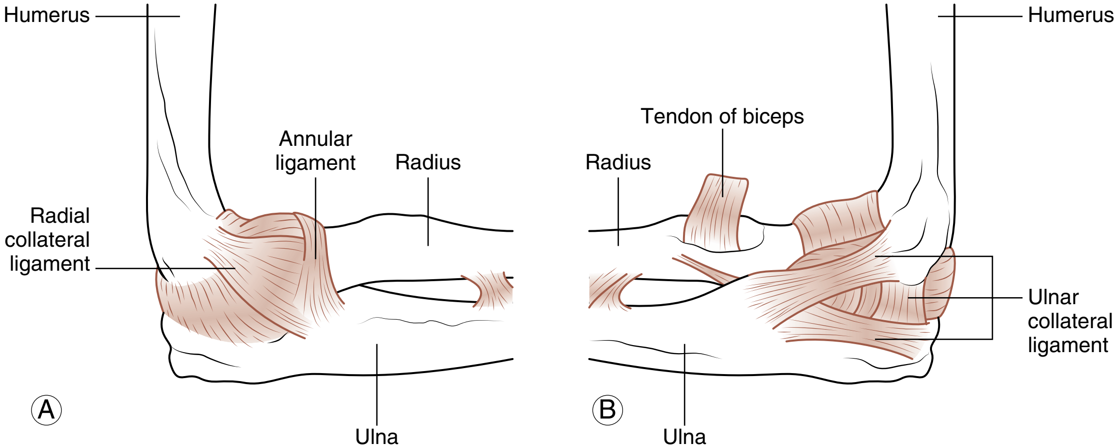


Fig 7.3 The elbow joint and its ligaments. To stress the ligaments of lateral elbow, (A) flex patient's elbow and supinate the hand. Grip the humerus near the elbow and the forearm near the wrist. Move the forearm medially. To stress the medial ligaments, (B) move the forearm laterally. Pain or laxity offer positive tests.

from the medial epicondyle to the coronoid process in front and the olecranon behind. There is also a stabilising transverse band between the front and back bands.

The radial collateral ligament

The radial collateral ligament (see Fig. 7.3) arises from the lateral epicondyle and joins the annular ligament at the head of the radius and the radial notch of the ulna. The fact that the main part of it inserts into another ligament rather than bone is very unusual: this leaves the radius free to rotate at the elbow, something which the ordinary arrangement of a collateral ligament would prevent. It limits varus angulation of the joint.

EXAMINATION

Look

It is surprisingly difficult to look at both elbows at once: they are best seen together from behind.

Swelling within the joint is most readily seen on the lateral, posterior side. There is a small triangular hollow over the lateral epicondyle and the head of the radius, best seen on the back of the elbow with the joint fully extended, and this is where swelling shows. This hollow also offers the best palpatory access to the bones within it. Unfortunately a swollen elbow tends to seek a position of 90 degrees of flexion to accommodate the fluid within a larger space than extension offers, and this makes it more difficult to see the contours of the posterior elbow.

Two injuries, between them the most severe elbow presentations likely to appear in a minor injury unit, the first common in children and the second more likely to happen to an adult, have similar clinical appearances: these are displaced supracondylar fracture and elbow dislocation. The similarity arises because both injuries result in a forward movement of the radius from the joint, leaving a boggy hollow at the back of the flexed elbow. The forearm bones will also move laterally if there is a dislocation and you will see and feel the head of the radius projecting on the outer side.

Olecranon bursitis leaves a red, egg-like swelling on the point of the elbow. Unlike a swelling which involves the joint, the patient will be comfortable with the arm straight. Look for broken or flaky skin, spreading cellulitic redness or lymphangitis tracking up towards the axilla as indicators of infection rather than the usual mechanical irritation.

Feel

Palpation should include all the bony landmarks. A patient with olecranon bursitis will have heat and a fluctuant swelling over the olecranon.

There is a triangular hollow visible on the posterolateral elbow when the joint is extended. If you place a fingertip in this hollow and press downwards you will feel the superior ridge of the head of the radius. You can confirm this by asking the patient to rotate the forearm. Upward pressure in the same hollow will bring you into contact with the inferior margin of the lateral epicondyle, a site which may be tender if the patient has tennis elbow.

The head of the radius is difficult to palpate because the extensor muscles of the wrist and hand cover the anterior aspect of the lateral elbow: this limits your access except

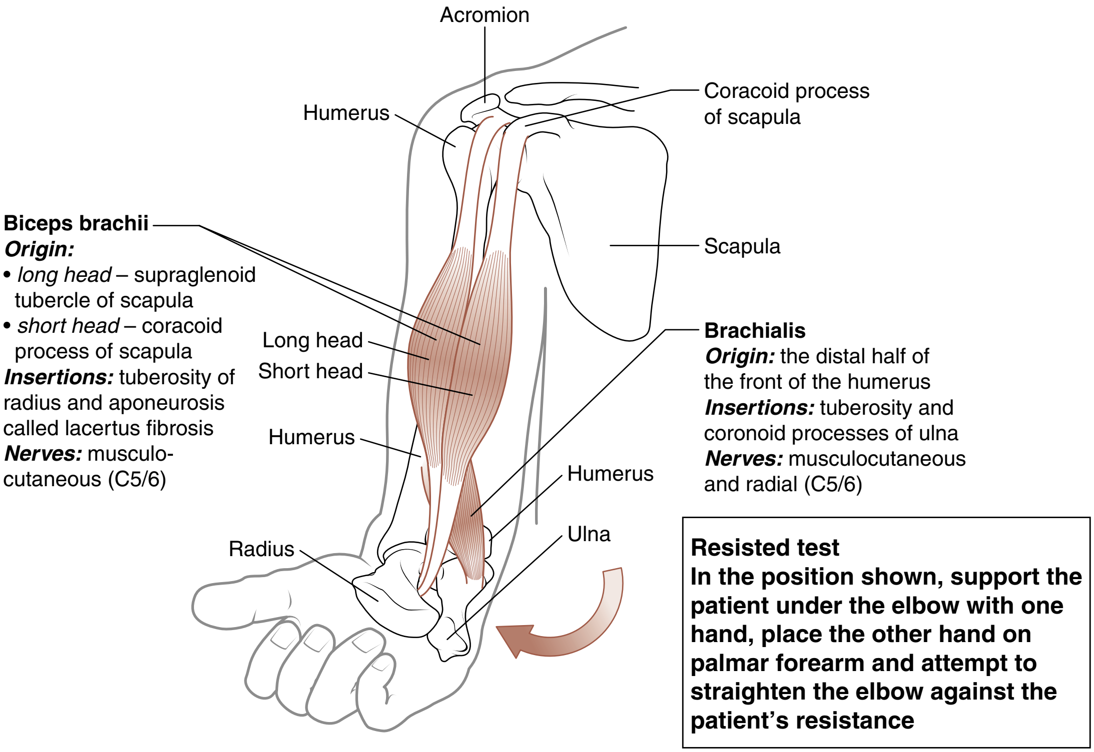


Fig 7.4 The flexors of the elbow.

on the lateral side. You can increase this access by asking the patient to pronate and supinate the forearm (turn the hand from palm-up to palm-down and back again) while you palpate.

Move

The main muscle groups, and their tests, are described in Figures 7.4 and 7.5. The collateral ligaments can be stressed in a similar manner to those of the knee (see Chapter 10), by the application of varus and valgus stresses to the joint with the elbow slightly flexed.

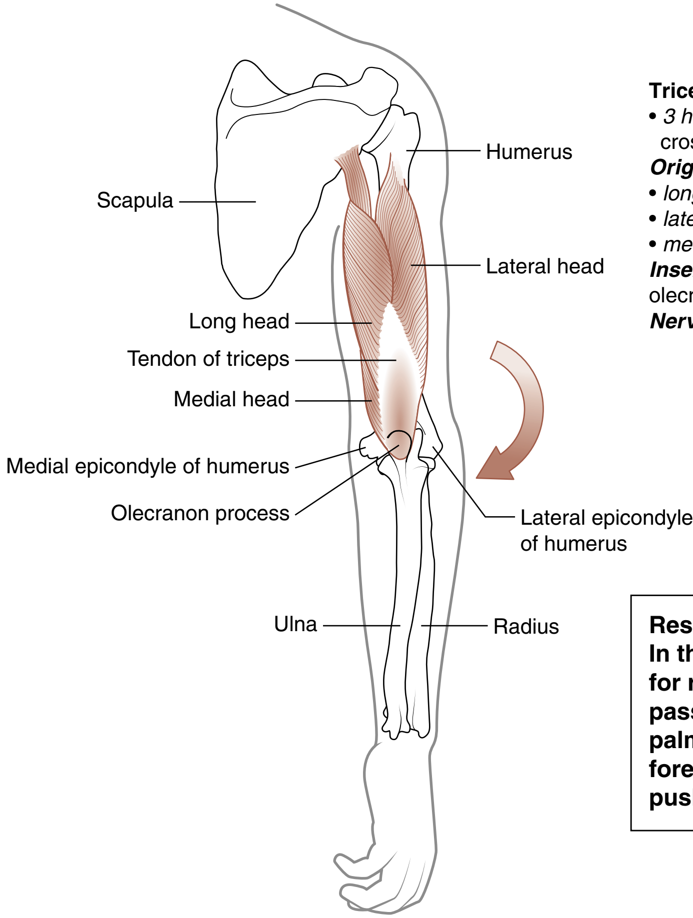
X-RAYS

The elbow is usually X-rayed in an anteroposterior (AP) view with the joint extended and a lateral view with the joint at 90 degrees of flexion (Fig. 7.6). It can be difficult for the patient to extend fully if the joint is swollen.

On the lateral view a line drawn downwards along the front margin of the shaft of the humerus will pass through the capitellum, and one third of the width of the capitellum will be in front of that line. A supracondylar fracture may cause forward angulation or displacement of the broken shaft of the humerus, leaving a smaller proportion of the capitellum showing in front of the line.

If a line is drawn along the middle of the length of the shaft of the radius, passing out through its head towards the humerus, that line will pass through the capitellum on both AP and lateral views. If it fails to do so, especially on the lateral view, then it is likely that the head of the radius is dislocated.

A particular feature of the interpretation of elbow X-rays is the use of **fat pads**. These are shadows, seen on the lateral view only, on the front and back margins of the distal humerus (Fig. 7.7), which help us to assess the severity of the injury. The shadows potentially represent a blood-filled joint space with the capsular membranes ballooned up. This is valuable because undisplaced fractures of the head of the radius in adults and of the supracondylar area in children can be difficult to see on X-ray: 'elevated' fat pads indicate a possible fracture. It is normal to see a fat pad lying almost parallel to the anterior margin of the humerus, but if the shadow angulates away from the humerus into a triangular shape it is abnormal. Any sign of a fat pad on the posterior margin is abnormal. Elevated fat pads are thought



Triceps brachii
- *3 heads*, only one of which crosses the shoulder joint

Origins:
- *long head* – infraglenoid tubercle of scapula;
- *lateral head* – proximal part of posterior humerus;
- *medial head* – distal half of posterior humerus

Insertion: by a common tendon, into posterior olecranon process of ulna

Nerve: radial (C7/8)

Resisted tests
In the same position as for resisted biceps test, pass your hand from palmar forearm to dorsal forearm, and attempt to push forearm into flexion

Fig 7.5 The extensors of the elbow.

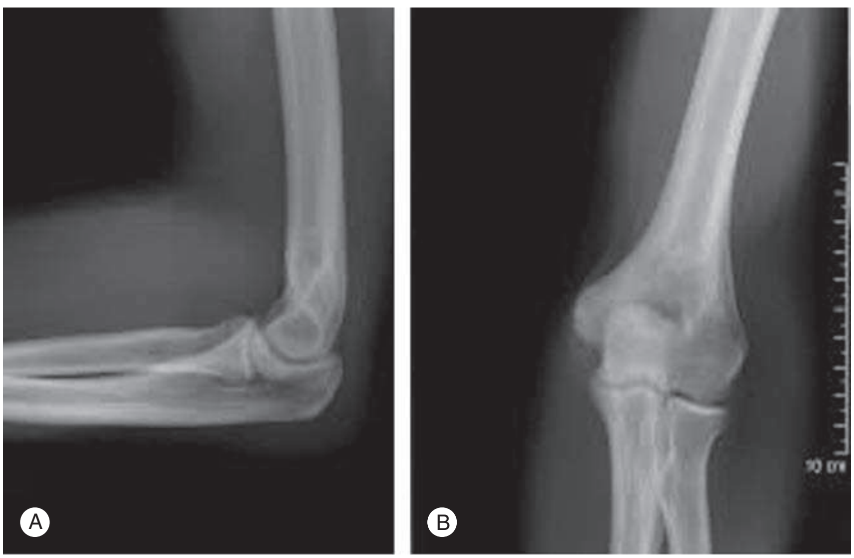


Fig 7.6 Standard X-rays of the elbow. (A) Lateral and (B) Anteroposterior views.

Fig 7.7 Elevated anterior and visible posterior fat pads suggest a fracture of the head of the radius.

Fig 7.8 A displaced fracture of the medial epicondyle, mimicking the trochlea.

to resemble the appearance of the sails on a yacht, and the term **sail sign** is used.

Children's elbows develop to bony maturity from no less than six separate ossification centres around the joint. The acronym **CRITOL** is used to indicate the usual order of this process – **C**apitellum, head of the **R**adius, medial (or **I**nternal) epicondyle, **T**rochlea, **O**lecranon and **L**ateral epicondyle. The process is on-going from toddler to adolescent. The key clinical application of CRITOL is that children can avulse the medial epicondyle (the 'I' in CRITOL) and the broken fragment can lodge in the elbow joint so that it mimics the appearance of an ossifying trochlea. If you see an ossifying trochlea on the AP view of the elbow but there is no sign of a medial epicondyle, go back: there can be no 'T' before 'I'. The 'trochlea' is actually a displaced medial epicondyle and the patient requires orthopaedic assistance (Fig. 7.8).

The presence of multiple ossification sites on the child's X-ray raises the question of whether an injury has caused a displacement of a lesser severity than the one described above. It is helpful when looking at the X-ray to superimpose upon it a mental image of the fully ossified, mature elbow. The separate ossification centres of the child should conform to the outline of the mature elbow as it will be. If a fragment lies outside that margin it is likely to be displaced.

INJURIES

Three fractures will be briefly discussed here: supracondylar, radial head and tip of olecranon. Also discussed is pulled elbow. Fracture/dislocations of the forearm will be discussed with the forearm.

Supracondylar fracture of the humerus

A supracondylar fracture occurs in the distal third of the humerus but proximal to the articular surface of the elbow. It is common in children. The fracture occurs from a fall on the outstretched hand. There is a weak point on the humerus where the hollows on the dorsum to accommodate the olecranon and on the anterior aspect to accommodate the coronoid process mean that the bone is thinner than elsewhere. There is also a physis, a growth plate, crossing the supracondylar area. Hyperextension of the elbow forces the olecranon into the dorsal hollow and causes fracture at that level.

The patient will have a tender distal humerus. A child will guard the arm and be unwilling to be examined. In cases where there is displacement, the distal fragment may be dislodged dorsally, and this may cause occlusion of the brachial artery. Occlusion of the artery can result in a **Volkmann's ischaemic contracture** of the forearm, the result of necrosis of avascular muscle tissue. It is important to check nerve and circulation repeatedly and obtain swift treatment for such injuries. It is also important to document that the patient has good pulses.

Radial head fracture

A radial head fracture is the commonest adult fracture at the elbow. It is usually caused by a fall on the outstretched hand which forces the radial head against the capitellum,

causing a depressed fracture. The outer margin of the head can be relatively intact, making it difficult to see the injury on X-ray and difficult to elicit tenderness on palpation.

The joint tends to fill with blood and this compels the patient to flex the elbow to 90 degrees. A fracture that does not displace the outer margin of the head may not diminish pronation and supination and it is common for patients to retain forearm movement but lose flexion and extension of the elbow. If the fracture is more severe and involves the neck of the radius forearm movement will also suffer.

The radial head will be tender if you can touch the part which is injured; increase your access by palpating through the range of pronation and supination. You will not always isolate tenderness. In some cases the only clinical signs of fracture will be a painful swollen elbow held at a right angle with pain vaguely localised to the front of the joint which increases dramatically if the patient tries to bend or straighten the arm. Those findings should elicit elbow X-rays and elevated fat pads on the lateral view should lead to clinical management of a fracture even if you are unable to see a definite injury on the image.

In a small number of cases severe fractures may require excision of the radial head and this can cause the radius to rise in relation to the ulna, with problems at the wrist joint. Recovery of forearm movement may not occur in conservatively treated fractures, and these sometimes need surgery later.

An uncomplicated fracture is normally managed in a collar and cuff sling until pain settles enough to mobilise the injury.

Olecranon fracture

The usual mechanism for an olecranon fracture is a fall onto the point of the elbow, which breaks the end of the olecranon. The triceps muscles are attached by a common tendon to this fragment and may displace it by pulling it away from the rest of the bone.

There will be tenderness and swelling and the patient will not be able to straighten the elbow against gravity.

Displaced fractures will need surgery, either for screws/wiring of the displaced fragment or, in some cases, excision of the piece and repair of the muscle.

On examination beware of the patient using gravity to let the elbow fall into extension. This can conceal the fact that the triceps muscle is no longer attached. However, the injury is usually so painful and so bruised and swollen that you would be likely to request an X-ray anyway and the fracture will be revealed.

Pulled elbow

Pulled elbow can occur until the head of the radius ossifies, which should happen before a child is 6 years old. Traction on the wrist (usually caused by swinging the child by the arms or reflexively pulling on the arm when a child falls while held by the hand) pulls the radius towards the wrist and allows the unformed head to slip out of the annular ligament.

The child will not use the arm and will be distressed by any attempt to examine the elbow or move the forearm. There may be some tenderness and swelling at the head of the radius.

The patient may complain of wrist rather than elbow pain, a result of the connection between the two sites, but the history should be of traction only. If the history is doubtful you may have to eliminate other possibilities. If the history and clinical appearance are clear you can proceed to reduction without X-rays.

There are two techniques for reduction:

- The supination method is widely used and is usually successful. Support the elbow with one hand, placing your thumb over the head of the radius. Hold the patient's hand and wrist in your other hand. Supinate the child's forearm to the end of the range and flex the elbow until the hand touches the shoulder. You will feel a soft click or 'ping' at the lateral elbow. Move quickly and smoothly but do not snatch at either movement or fail to perform them completely. The patient will be surprised and then distressed, but the reduction should be complete before there is any resistance. The child can then be encouraged to reach for a toy, and will quickly resume normal use of the arm.
- The second technique is simpler and is gaining ground as the more likely to succeed. Support the elbow and hold the wrist as before but, instead of supinating and flexing the forearm, simply pronate to the end of the range of movement.

The problem may recur (sometimes several times) and it can occur in both elbows until the head of the radius ossifies.

If reduction is unsuccessful put the arm in a sling and arrange a review in a day or two. The problem will usually have settled by then.

Olecranon bursitis

Pressure or friction can cause inflammation of the olecranon bursa on the point of the elbow, a condition known as **student's elbow**. A blow to the olecranon can also cause a bleed into the bursa, which irritates the synovial tissue and causes inflammation. A wound or flaky skin can admit infection at the elbow and cause a septic bursitis.

There will be an egg-like swelling, large and softly fluctuant, red, hot and tender, over the olecranon process. Pain caused by increasing pressure on the swelling will limit flexion of the elbow but extension should be unaffected

and, in fact, preferred by the patient, a feature which distinguishes bursitis from a joint swelling. If bleeding has occurred, there should be a history of trauma, and bruising may be visible. If there is infection, other signs may be present, such as malaise and pyrexia, and there may be broken skin in the vicinity of the swelling. The infection may show local signs of spread such as expanding cellulitis, red tracking lines moving up towards the axilla and tender lymph nodes in the axilla itself.

A simple bursitis should settle with rest. A bleed into the bursa can take months to disperse but there is reluctance to aspirate the collection because of the risk of introducing infection. An infected bursa may require aspiration to confirm the diagnosis and identify the pathogen.

Epicondylitis

Epicondylitis is an overuse strain on the common tendinous insertions of the extrinsic extensor and flexor muscles of the wrist and hand at the lateral and medial epicondyles of the humerus, respectively (Fig. 7.9). It can give rise to inflammation at their tenoperiosteal junctions. These problems are called lateral epicondylitis or **tennis elbow** and medial epicondylitis or **golfer's elbow**. Tennis elbow is more common and tends to be more troublesome.

There is a history of pain at the appropriate side of the elbow, which can radiate up and down, with pain and impairment of wrist and hand movements. Elbow movements are not affected. The epicondyle is usually tender.

Both problems do settle but may take a long time to do so. The general practitioner may give a steroid injection. Physiotherapy manipulations are sometimes tried, as are rest and, occasionally, surgery. A wrist splint can reduce painful movements and strapping around the upper forearm to redistribute tension on the epicondyles helps some patients.

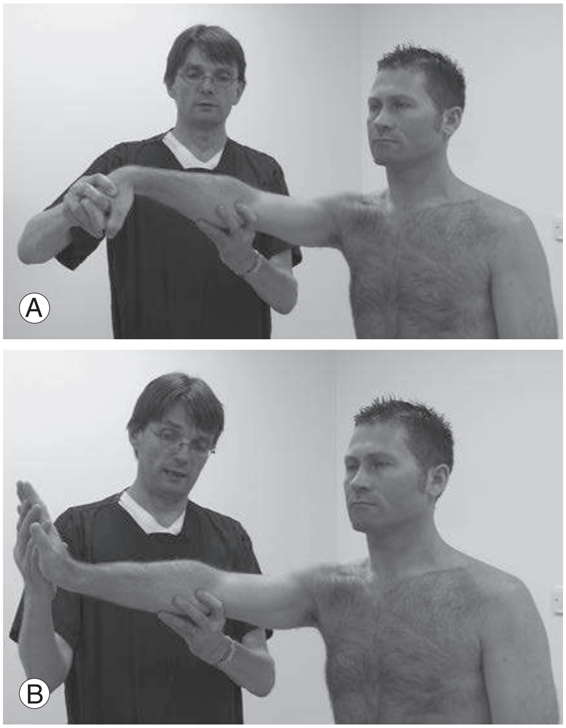


Fig 7.9 Epicondylitis. A, To test for tennis elbow, passively stress the common extensor tendon by flexing the wrist with elbow extended. Pain at the lateral epicondyle is positive. B, To test for golfer's elbow, passively stress the flexors of the wrist by extending the wrist with the elbow extended. Pain at the medial epicondyle is positive.

Chapter

8

The forearm, wrist and hand

CONTENTS

INTRODUCTION

The hand is second only to the face as an embodiment of values which transcend the practical towards the expressive, the psychological and the spiritual. Along with the face, it is the other part of our bodies which is customarily exposed. It is cosmetically important. It is the instrument by which our brains act upon the world. The arm puts the hand where it is needed: we then use it for tasks requiring dexterity, sensitivity, precision and power. It is an instrument of communication, used to reinforce speech or instead of it. When we wish to convey emotion, we use touch. It is often our chosen instrument for gestures which convey our beliefs; praying, salutes, symbolic movements. A loss of normal appearance in the hand will cause us distress; a loss of normal function may reduce our capacity to be autonomous, may take away our livelihood.

It is not uncommon for a patient with a hand injury to say, at some point in the consultation, ‘I have come because I need my hands’. Everyone needs his or her hands. It may not always be about being a concert pianist but it may be about being able to do up your own buttons. If you fail to manage a hand injury correctly you may cause a patient a lifetime of difficulty and you may expose yourself to legal action.

ANATOMY

Terminology

The terminology used to describe structures and positions of the hand is somewhat different to other parts of the body (Figs 8.1 and 8.2). This is because the positions of other areas are named in relation to a fixed point, the midline of the body. The mobility of the arm and the hand’s capacity to be rotated about the axis of the arm makes it difficult to use these reference points. Instead, its positions are described in terms of fixed internal relationships and are descriptive rather than directional names.

The main surfaces of the hand are **palmar** (Figs 8.2 and 8.3) for the palm side and **dorsal** for the back. The palm side is also called **volar**. The two borders between the palmar and dorsal sides are named for the forearm bones. In the anatomical position, with the palm forward, or supine, the radius lies on the lateral side of the forearm between the outer side of the elbow and the thumb side of the wrist. When the hand is turned to a prone, palm backwards position, the radius is carried over to the inner side of the arm at the wrist although it remains on the outer side of the arm at the elbow. When the radius turns over in that manner it carries the thumb with it. This means that the relationship between radius and thumb is consistent, regardless of any other changes which occur. Therefore the margin of the hand which is on the thumb side, and the margin of any finger which is toward the thumb, is called **radial**. The margins of the same parts which lie on the side of the little finger are called **ulnar**.

The fingers are named **thumb**, **index**, **middle**, **ring** and **little** because the issue of whether the thumb is to be counted causes confusion if they are numbered. The palm is divided into three zones. The **thenar eminence** is the mound of muscle which covers the metacarpal of the thumb. The **hypothenar** covers the metacarpal of the little finger. Between these lies the **midpalm**.

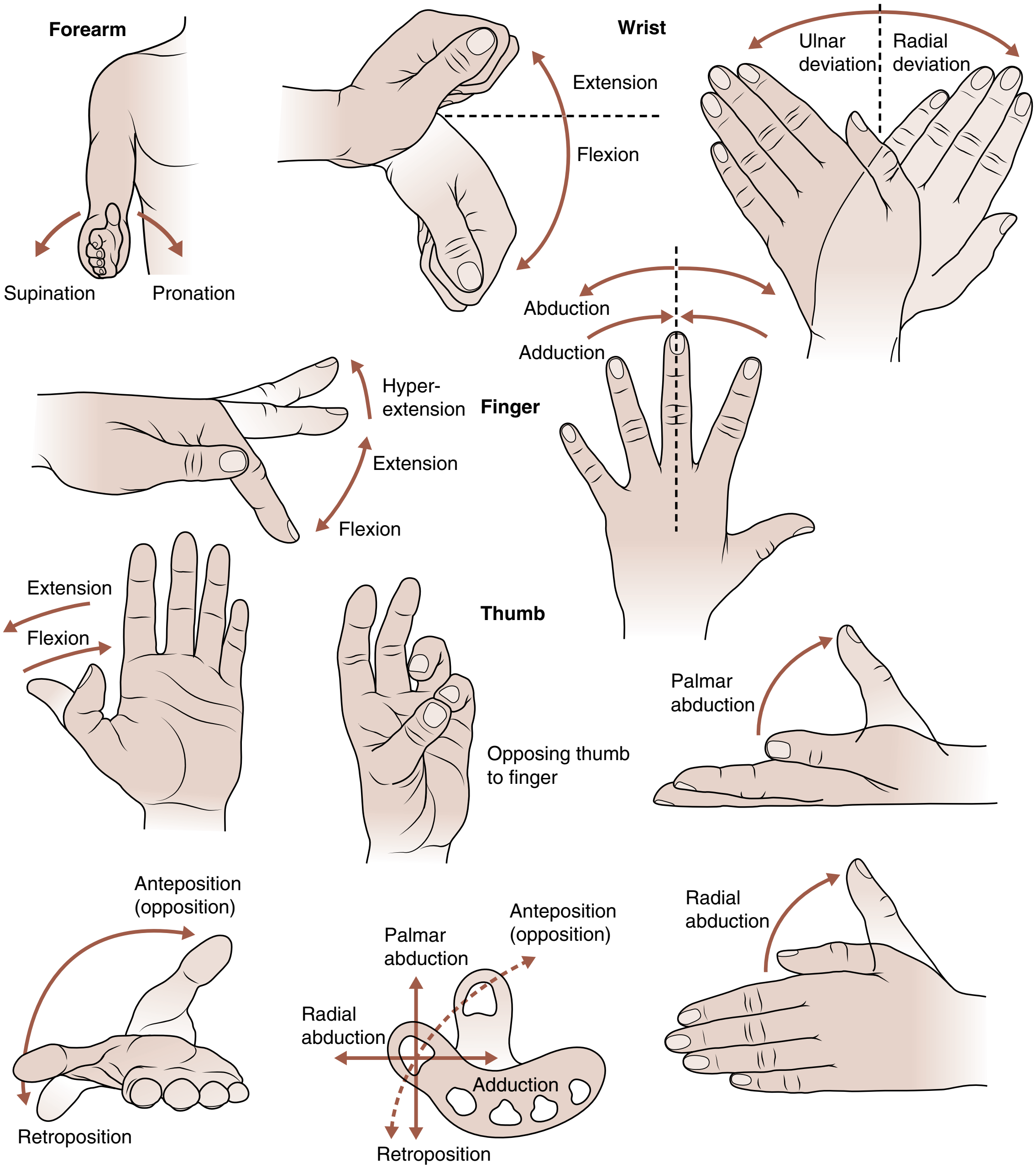


Fig 8.1 Terminology of positions of the hand.
Source: From American Society for Surgery of the Hand,1990. The Hand: Examination and Diagnosis, third ed. Churchill Livingstone.

Every bone in the hand and wrist (see Fig. 8.3) belongs to one of four groups: the distal part of the forearm, the **carpals**, **metacarpals** and **phalanges**.

The eight carpal bones lie in two transverse rows, **proximal** and **distal**, and they articulate with each other in a complex manner, side to side, up and down and obliquely. The proximal row also articulates with the distal surfaces of the forearm bones, the **radius** and **ulna**, to form the wrist joint. The distal row articulates with the bases of the five metacarpals and with the proximal row of carpals. The

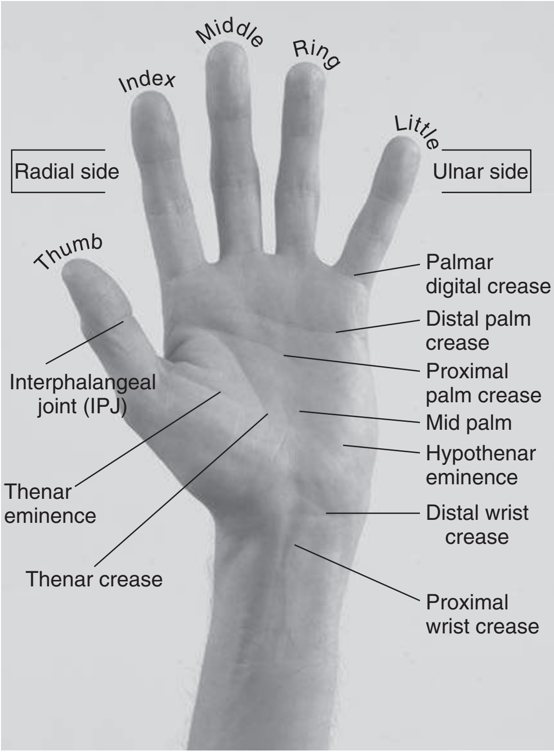


Fig 8.2 The wrist and hand: surface markings and terminology.

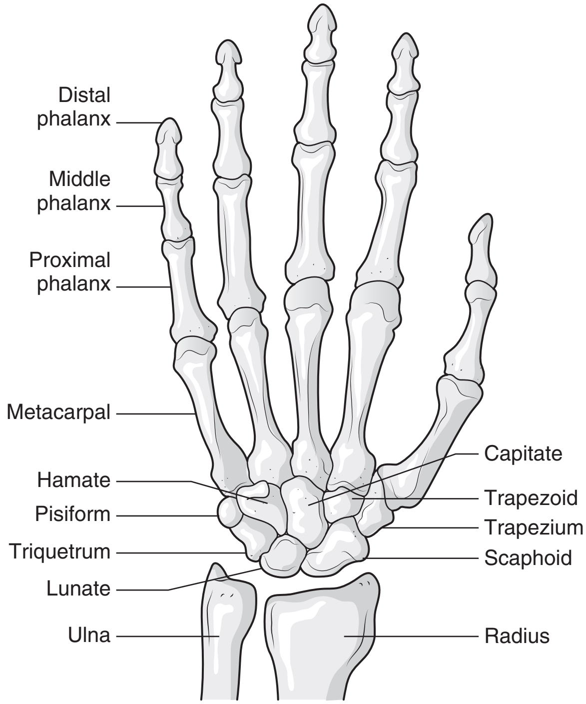


Fig 8.3 Palmar view of the bones of the wrist and hand.

carpal bones are sometimes classified in longitudinal rather than transverse groups and this may do more to express their functions and relationships: the axis of the opposing thumb, moving across the palm, scaphoid and trapezium; the stabilising midline axis of lunate, capitate and trapezoid; and the mobile axis of the little finger, moving towards the thumb, the triquerum and hamate. The pisiform is excluded from this model because it is a sesamoid bone, accessible only on the palm, existing as an attachment point for muscle rather than as an articulated part of the skeletal frame.

The metacarpal bones provide the main bony structure of the palm. They are named for the finger that they support. At the distal end, or head, each metacarpal articulates with the proximal phalanx of a finger.

The thumb has two phalanges: proximal and distal. The other fingers have three phalanges: proximal, middle and distal.

The joint between metacarpal and finger is the **metacarpophalangeal joint** (**MCPJ**). The proximal/middle phalanx joint is the **proximal interphalangeal joint** (**PIPJ**). The middle/distal phalanx joint is the **distal interphalangeal joint** (**DIPJ**). The articulation between the phalanges of the thumb is the **interphalangeal joint** (**IPJ**).

The bones of the forearm

The radius and the ulna are the two bones of the forearm, passing from elbow to wrist. The elbow has been described in Chapter 7. The wrist joint is formed mainly by the articulation of the distal end of the radius with the proximal carpal row. The ulna does not articulate directly with the carpal bones (Fig. 8.4).

The radius is a long, arched bone. In the neutral, supine position, it lies on the lateral side of the forearm alongside the ulna and articulates with it at two joints which are separated by almost the entire length of the bones. In spite of this separation, these two joints are best considered, for understanding of function and the problems caused by trauma, as a single unit of movement. Proximally, the radial head rotates on its own axis. The radial head is in contact with the capitellum of the humerus but has much less to do with the elbow joint than the ulna. It is held against the proximal ulna by a ligamentous loop, the **annular ligament**, which leaves it free to rotate about its own axis. Distally, the radius is joined to the ulna by a combined cartilage and ligament structure which arises on the ulnar side of the wrist joint. Along the length of the radius and ulna a tough **interosseous membrane** links the two bones. This tissue is not so strong as ligament but it is firm enough to be an attachment point for muscles. The radius can travel 180

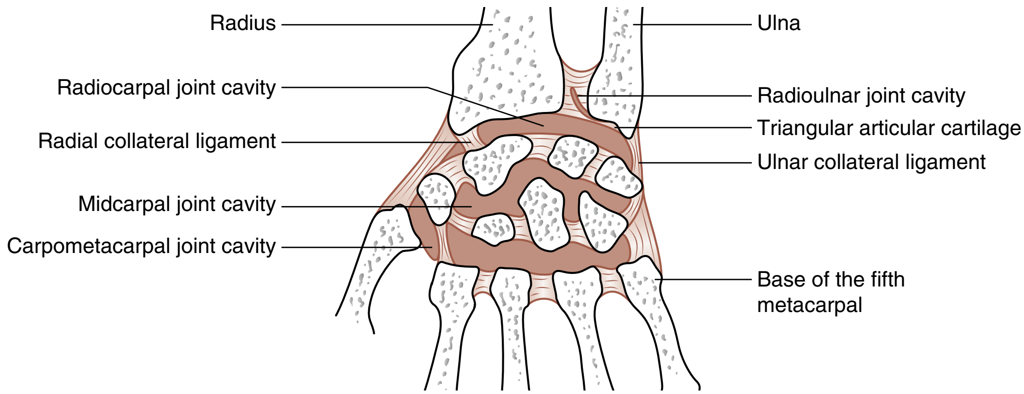


Fig 8.4 The ligaments and joint capsules of the wrist, carpal and carpometacarpal joints.

degrees in an arc, passing around the ulna. The ulna functions as a pivot, a foundation, for the radius as it carries the hand between the palm forwards (**supine**) and the palm backwards (**prone**) positions. In this mutually dependent relationship the relative length of these two bones, and the space between them, must be correctly maintained. Any bony injury which changes the relationship between the radius and ulna or disrupts an important soft tissue attachment may be more crippling than simple X-ray appearances would suggest.

The wrist joint (radiocarpal)

The expanded articular surface of the distal radius is a concave triangle with two cartilage-coated sockets for articulation with the **scaphoid** and the **lunate**. The proximal row of carpal bones is more curved in its outline than the distal radius, and moves upon it in a gliding fashion.

The radius and the ulna each have a **styloid process**, a button of bone on their carpal articular surfaces for the attachment of ligaments. The radial styloid is distal to the ulnar styloid, and the dorsal margin of the radius, at the wrist, continues distal to the palmar margin; this creates a two-way slope and means that the neutral position of the hand tends to be slightly palmar and ulnar.

On the dorsum of the distal radius, in the centre, is a projection called **Lister's tubercle**, best felt with the wrist in flexion: it creates channels for the passage of dorsal tendons of the thumb, two extensors and an abductor. These tendons move laterally as well as longitudinally because of the mobility of the thumb around the palm and they need solid anchorage in their grooves on the dorsal forearm. Lister's tubercle lies in line with the third finger and the capitate and is a useful landmark for palpation of the midcarpal bones.

Box 8.1 Wrist statistics: The radiocarpal joint

- Capsular pattern: equal restriction of flexion and extension.
- Joint positions: loose packed is 10° wrist flexion with slight ulnar deviation (the neutral position of the hand at rest); close packed is full extension with radial deviation.
- Flexion 0–80°; endfeel firm; capsule and ligament stretch.
- Extension 0–70°; endfeel firm; capsule and ligament stretch.
- Ulnar deviation 0–30°; endfeel firm; capsule and ligament stretch.
- Radial deviation 0–20°; endfeel firm and capsule and ligament stretch or endfeel hard and scaphoid meets radial styloid.

The wrist joint allows movements of flexion and extension and movements to the sides called **radial deviation** and **ulnar deviation** (Box 8.1). A sequential combination of these movements in either direction, causing the hand to rotate at the wrist, is called circumduction. These wrist movements combine with rotation of the forearm to allow precise placement of the hand in any plane.

The carpal bones

In the proximal row of carpal bones, from radial to ulnar sides, lie the **scaphoid, lunate, triquetrum** and **pisiform** (Fig. 8.5). The pisiform is a **sesamoid** bone, a bone which is attached to tendons in order to give muscle greater mechanical advantage. It lies directly in front of the triquetrum, on the palmar aspect, and cannot be palpated on the dorsal wrist. The distal carpal row comprises the **trapezium**, **trapezoid**, **capitate** and **hamate**.

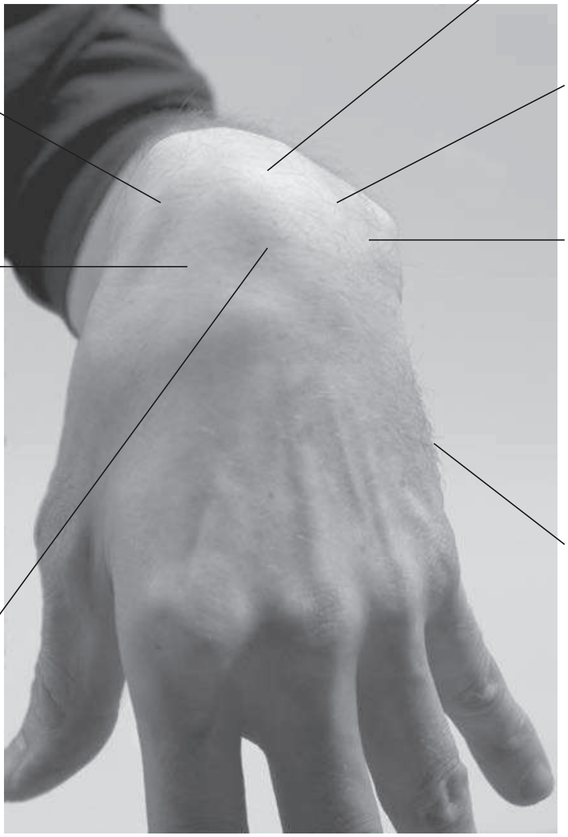


Fig 8.5 Examination of the dorsal carpal bones of the wrist.

The carpal bones are six-sided. They articulate with each other, with the forearm and with the five metacarpals. Their articular surfaces are covered with cartilage and their palmar and dorsal surfaces are rough for the attachment of ligaments.

The carpal bones form an arch from side to side, concave on the palm and convex on the dorsum. Opposition of the thumb depends upon the concavity of the palmar arch. The wrist is more stable in flexion than extension, partly because of its palmar concavity but also because of the strength of its ligaments. The palmar concavity of the wrist is also important in balancing the action of the extensor muscles of the wrist with the flexors of the fingers. The dorsal curve is longer than the palmar and the individual bones tend to be wider on the dorsal surface. This means that if they dislocate, they will normally do so dorsally. The lunate is an exception and is also the carpal bone most likely to dislocate.

The carpus is a transition from the levers of the forearm to the complex adaptability of the hand: each carpal bone has a distinctive shape and an individual role. They combine to provide the two conflicting needs of the transition: stability and movement.

Most wrist movements occur at the radiocarpal and the midcarpal joints. The proximal row, the key to these movements, is not a simple articular block tilting in two planes. The bones of the proximal row, especially the scaphoid and the lunate, change their positions by mutual displacement (by gliding obliquely, rotating and rocking) so that a convex surface will be presented to the distal radius at all stages of movement, and a concave hollow will receive the distal row.

The distal row, with the capitate at its core, is much less mobile than the proximal. The metacarpals of the index and middle fingers are rigidly joined to it to form the fixed axis of the hand. There is more mobility at the articulations

of the hamate with the fourth and fifth metacarpals; consequently, the ring and little fingers can move across the palm into opposition. The saddle joint of the trapezium with the base of the metacarpal of the thumb is the most mobile single joint in the hand, permitting a complete range of circumduction at the base of the thumb:

- The scaphoid is the largest bone in the proximal row. The **tubercle** of the scaphoid, a round projection on the distal palmar surface, is an attachment for the **flexor retinaculum**, which forms the fibrous roof of the bony channel called the **carpal tunnel.** The scaphoid articulates with five bones: the radius proximally, lunate and capitate ulnarly, and trapezium and trapezoid distally. It crosses the two transverse carpal rows, making it prone to stress in its mid-section (called the **waist**). It is, by far, the most frequently injured carpal bone. Commonly, a fall on the outstretched hand extends the wrist and causes the scaphoid to break against the dorsal lip of the radius. Other mechanisms of injury, including forced flexion of the wrist, are also associated with fracture of the scaphoid. The scaphoid is pierced on its dorsum by nutrient foramina, holes in the bone which allow the passage of blood vessels. In many people these foramina are only found on the distal part of the bone, which means that, for them, the bone is perfused in a distal to proximal direction. A fracture through the waist of the scaphoid can cut the blood supply to the proximal part if the fracture does not unite. This can cause avascular necrosis of the proximal scaphoid and, later, serious disability of the hand. The scaphoid is both highly mobile and a major source of the stability of the carpus.
- The lunate takes its name from its crescent-moon shape. The bone has, in fact, a crescent appearance on two of its aspects: it has two concave curves for articulation with the scaphoid on its radial side and with the inferior aspect of the capitate. It articulates with the triquetrum on its ulnar side, and, when the wrist is in ulnar deviation it touches the nearest corner of the hamate.
- The triquetrum is a pyramidal bone which articulates proximally with the ulnar triangular fibrocartilage when the wrist is in ulnar deviation. It articulates with the lunate radially and the hamate distally. On its palmar surface it has an oval, smooth articular surface for the pisiform.
- The pisiform is pea-shaped. It is a sesamoid bone, an attachment point for tendons and ligaments that does not otherwise contribute to the bony architecture of the carpal wrist. It is only accessible on the volar surface. It articulates dorsally with the triquetrum. It is covered by the hypothenar muscles but is easily felt and can also be located by following the tendon of the flexor carpi ulnaris muscle from the volar, ulnar side of the distal forearm to its junction with the bone. It is the proximal attachment point on the ulnar side of the wrist (along with the more distal hook of the hamate) for the flexor retinaculum which covers the carpal tunnel.
- The trapezium lies at the radial end of the distal carpal row, articulating proximally with the scaphoid, distally with the base of the first metacarpal (and, to a lesser extent, with the base of the second metacarpal) and, on the ulnar side, with the trapezoid. It has a volar ridge, or tubercle, which allows attachment of the flexor retinaculum, the fibrous roof of the carpal tunnel. Its articulation with the first metacarpal is distinctive, a 'saddle'-shaped joint which engages with a reciprocally shaped base of the metacarpal to allow a wide range of movement at that joint. Other grooves and roughened surfaces allow the passage of tendons and attachment of ligaments.
- The trapezoid is a small bone lying between the scaphoid proximally, the trapezium radially, the capitate on the ulnar side and the base of the second metacarpal distally.
- The capitate is a central pillar of the carpal bones, resting proximally in the main hollow of the lunate. Its widest, distal articulation is with the base of the third metacarpal, but it also meets the near corners of the bases of the second and fourth metacarpals. Radially, it articulates with the scaphoid and trapezoid and on the ulnar side it borders the hamate.
- The hamate is on the ulnar side of the distal carpal row. It is a triangle whose apex points upwards, towards the wrist. This apex meets the lunate proximally when the wrist is in ulnar deviation, and its ulnar border articulates with the triquetrum. It articulates radially with the capitate and distally with the near corner of the base of the fourth metacarpal, and with the base of the fifth metacarpal. On its volar surface is a curved (in a radial direction) projection called the hook of the hamate. The hook is covered by hypothenar muscle and is more difficult to palpate than its bony appearance would suggest. The flexor retinaculum is attached to the tip of the hook (as well as to the pisiform on the ulnar side of the carpal wrist) and crosses to the scaphoid and trapezium to form the fibrous roof of the carpal tunnel. A groove called the **canal of Guyon** formed by a passage between the pisiform and the hook of the hamate carries the deep branch of the ulnar nerve.

The carpal tunnel

The carpal tunnel is a narrow passage running from forearm to palm, with the midline carpal bones from both rows (the lunate and the capitate) for its floor. The palmar prominences of the carpal bones at both sides form its walls, and it has a roof of fibrous tissue known as the **flexor retinaculum**. Without its contents, the tunnel is deep enough to receive a fingertip.

On the radial side, the wall of the tunnel is formed, proximally, by the tubercle of the scaphoid (which can be felt at the base of the thenar eminence) and, distally, by the tubercle of the trapezium. On the ulnar side, the pisiform, proximally (which can be felt at the proximal border of the hypothenar eminence), and the hook of the hamate, distally, form the wall.

The flexor tendons of the fingers and the median nerve of the hand pass through this restricted space. Excess fluid in the wrist can cause compression in the tunnel and disability of the hand, with the symptoms of compression of the median nerve, a problem called carpal tunnel syndrome.

The bones of the hand

The skeleton of the hand is a succession of long bones (the metacarpals' digital appearance disguised by the flesh of the palm) whose structure and manner of combination equip them for a wide range of activities of great variety, power and subtlety, usually by movements which result in the coming together of the fingers in front of the palm; adduction, rotation, flexion and opposition. These movements vary to allow different forms of contact between the fingers depending on the needs of the task for power, finesse, complexity and precision. The joints are all simple synovial hinges, except those of the MCPJs of the index to little fingers, which are condyloid and capable of abduction and adduction as well as flexion and extension (see Fig. 8.3) and that of the base of the first metacarpal, the 'saddle joint' with the trapezium, the most versatile joint in the hand.

The particular mobility of the thumb, and especially its capacity to 'oppose' the other fingers, is the source of the human hand's unique dexterity and power. When the thumb is opposed, the palmar surface of its distal phalanx is pressed against the same surface of another finger. This position is quite different to the pinch grip, which can be obtained by flexing the distal phalanges of two fingers and putting the tips together in the 'threading a needle' posture. It is a useful illustration of opposition to think of this needle-threading action and then to compare it with the posture of the hand when holding a pen.

Ligaments

The annular ligament of the proximal radioulnar joint has been mentioned. At the wrist the ulna does not articulate with the carpal bones. It is separated from them by a thick pad, the **triangular fibrocartilage** (see Fig. 8.4), which also articulates by ligamentous fibres with the distal radius, controlling and permitting the range of pronation and supination at that joint. The ulna is linked to the carpus by the **ulnolunate ligament** and the **ulnar collateral ligament**.

There are many radiocarpal ligaments; these are the main stabilisers of the wrist and are chiefly arranged across the palmar aspect of the carpus. The **space of Poirier** is a thinning of the palmar carpal distribution in front of the lunate: it is this relative weakness which allows the lunate to dislocate anteriorly with a rupture of the ligament.

The metacarpal bones have a system of interconnected transverse ligaments in the palm, reinforced by the general density of fascia and a large number of tendons.

The digits have two collateral ligaments at each joint, inserted on the palmar surface on both sides to a **volar plate** (Fig. 8.6). The volar plate is a rectangle of cartilage which is inserted into the base of the distal bone at the joint, a small anterior flap. It lies in front of the proximal bone, but is not joined to it. When the finger is straightened the collateral ligaments become tight and pull the plate against the palm side of the joint. This limits extension at the three joints of the finger to varying degrees. The PIPJ is the most tightly controlled, reaching only neutral position, even by passive stretching, while the other joints can be taken well past that point. A hyperextension injury of the finger is therefore most likely to damage the proximal joint because, quite simply, it will be the first to go. It is very common for the volar plate to avulse its attachment point on the base of the middle phalanx.

The ulnar collateral ligament of the MCPJ of the thumb is often implicated in abduction injury of that digit.

The muscles of the forearm, wrist and hand

The muscles which supply the forearm, wrist and hand are in two groups, the **extrinsic** and the **intrinsic** muscles. The

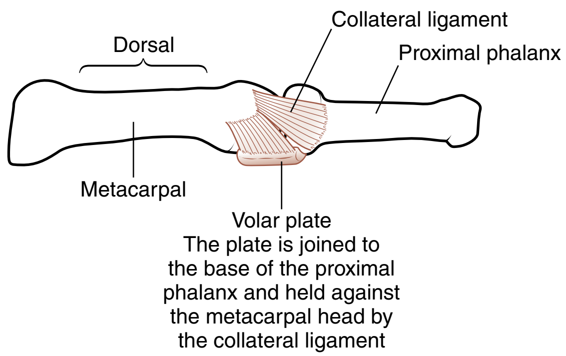


Fig 8.6 The volar plate and collateral ligaments of the hand.

extrinsic muscles travel into the wrist and hand from outside. Intrinsic muscles arise within and insert into the hand.

The extrinsics are also in two groups, the **flexors** and the **extensors**. Some of the muscles in the lateral group of extrinsics, the extensors, arise from the supracondylar ridge of the humerus, and many of the extrinsics on both sides of the elbow cross that joint from common tendons at the epicondyles of the humerus. They therefore travel a long way, some of them crossing four joints. Their tendons are long and superficial, and they are more vulnerable to injury than the intrinsics.

Assessment of the extrinsic muscles is a task which is performed repeatedly on every working day in any minor injury area.

The extrinsic muscles mainly perform tasks of flexion and extension, where the angle of the muscle's action is not complicated. This, if you consider it, is an inevitable consequence of their length. The more complex movements within the hand, when fingers are brought together and separated in various ways, require muscles to act at angles, and at joints within the hand, which would be difficult to achieve from outside the hand. The intrinsic muscles have therefore more to do with movements such as abduction, adduction and opposition of the fingers. The intrinsic muscles also contribute to coordination of hand movement.

The words **longus** and **brevis**, 'long' and 'short', are common elements in muscle names in the hand. These are not poetic additions. Whenever there is a muscle named 'longus' there will be another of the same name called 'brevis'. Unfortunately, although the muscles will have some common theme, there is no formula for deducing the exact nature of the relationship between the namesakes.

The extrinsics are arranged as follows:

- The extensors arise from the outer side of the arm and pass down to wrist and hand on the dorsum of the forearm, from the supracondylar ridge of the humerus (**extensor carpi radialis longus**, **ECRL**), from the common extensor tendon at the lateral epicondyle of the humerus (**extensor carpi radialis brevis, ECRB; extensor carpi ulnaris, ECU; extensor communis digitorum, ECD; extensor digiti minimi, EDM**), and from the bones of the forearm and the interosseous membrane between the radius and ulna (**extensor indicis proprius, EIP; extensor pollicis longus, EPL; extensor pollicis brevis, EPB; abductor pollicis longus, APL**). This group also includes other muscles which act on the elbow and forearm, including the supinator. The word carpus always refers to the wrist and pollicis to the thumb.
- On the medial side, none of the flexors arise from the supracondylar ridge, and this gives a different appearance to the two sides of the elbow. The medial epicondyle is the highest point of attachment of the flexors, and, because it is not clothed in muscle like the lateral epicondyle, it is more prominent and easier to find. The flexors arise from the common tendon of the medial epicondyle of the humerus and pass down the palmar surface of the forearm to the wrist and hand (**flexor carpi radialis, FCR;** part of the **flexor carpi ulnaris, FCU; palmaris longus, PL;** part of the **flexor pollicis longus, FPL;** part of the **flexor digitorum superficialis, FDS**), and from the bones of the forearm and the interosseous membrane (part of the FCU, part of the FPL, part of the FDS). This group also includes muscles which act on the elbow and forearm, and pronators.
- A dividing line between the two groups of muscles can be seen on the dorsal forearm in the groove which runs along the ulna from the olecranon to the distal ulna at the wrist.
- The flexors are generally more powerful because the significant functions of the hand are all performed on the palm side, the skin is thicker there and there are pads of intrinsic muscles on that side while none are seen on the dorsum.

The presentation of the intrinsic muscles in textbooks in different groups can make it harder to discern their overall arrangement, which is integrated across the groups. There are 18 muscles divided into five groups. Four of these groups, supplying 14 of the muscles, provide each digit with the capacity to abduct and adduct each finger, and the thumb and little finger with the ability to oppose each other, and also with an extra flexor each in addition to the extrinsic supply. You will see slight variations in the way that the muscles are classed and described, and there are variations in individual anatomy.

The abductors of the fingers are the **dorsal interosseous** muscles, meaning that they lie between bones and towards the back of the hand. The bones that they lie between in this case are the metacarpals and the fingers. In the hand abduction and adduction occur around the axis of the middle finger. Spread your fingers and observe the movements which actually occur. The middle finger stays where it is, the thumb and index finger move in a radial direction and the ring and little fingers move in an ulnar direction. The middle finger can actually abduct in either direction because it is the midline of the hand. It therefore has a dorsal interosseous muscle on both sides: this double supply of abductors means that it does not require an adductor muscle. Therefore the distribution of the dorsal interosseous muscles is: one muscle on both sides of middle finger, one on the radial side of the index finger and one on the ulnar side of the ring finger. The abductor of the thumb is a thenar muscle and that of the little finger is hypothenar.

The **palmar interosseous** muscles are adductors. There are three (some classifications describe a fourth one arising

from the thumb): one on the radial side of the little and ring fingers, and one on the ulnar side of the index finger. The middle finger needs no adductor because it has two abductors and the thumb has its own adductor in the thenar group. The little finger's adductor is classed with the palmar interosseous muscles rather than the hypothenar muscles.

The four **thenar** muscles cover the trapezium and the first metacarpal on the palm, creating the rounded mound of muscle which is such a distinctive feature of the hand. Their individual functions are described below, but remember that they work together and tend to share the tasks of any given movement.

Two muscles form the superficial layer, the **abductor pollicis brevis** (**APB**) and the **flexor pollicis brevis** (**FPB**). There is also a second layer, the 'deep head' of the FPB, below the superficial layer. The APB and FPB are in close proximity and both arise from the flexor retinaculum and the radial carpal bones, and both insert into the base of the proximal phalanx of the thumb. However, a slight difference in their positions in relation to the collateral ligaments of the thumb dictates the difference in their action. The APB is the more proximal and radial muscle and is aligned with the collateral ligaments so that its contraction lifts the whole thumb into palmar abduction. The FPB inserts into the proximal phalanx of the thumb palmar to the APB, and its tendon is attached to one of two sesamoid bones which are seen on X-rays at the palmar side of the MCPJ of the thumb. Its causes the thumb to flex at the MCPJ while it can remain extended at the IPJ. The value of this pattern of flexion is that the palmar surface of the distal phalanx can be brought into opposition with the same surfaces of other fingers, in the way that one might hold a pen. FPL flexion at the IPJ causes the tip of the thumb to meet the tips of other fingers in a 'pinch grip', as when one threads a needle. There is an extrinsic long abductor of the thumb, the APL. The difference between the action of APL and APB is that the APL is more involved in radial abduction of the thumb.

Below the superficial layer, the **opponens pollicis** (**OP**) arises from the flexor retinaculum and the trapezium, a similar arrangement to the APB and FPB, but its insertion is unusual. Instead of crossing a joint and inserting a narrow tendon into bone just beyond, it fans out and inserts into the entire length of the first metacarpal on the radial border. It causes the metacarpal to rotate upon its own axis as the thumb moves towards the palm. Opposition gives the palm a cupped look which does not happen with pure flexion. This allows the thumb to be brought to the other fingers without complete dependence on the flexors of the MCPJ and the IPJ. When the thumb crosses the palm by the use of flexors only, it is seen in profile against the palm. When the thumb crosses the palm using the muscle of opposition, a large part of its dorsal surface can be seen against the palm. Opposition allows the thumb to meet the other fingers on the palmar surfaces, rather than just the tips, a more stable and powerful form of grip.

The most dorsal of the four muscles, one which is not always classed in the thenar group, is the **adductor pollicis** (**AP**). This muscle has two parts, the oblique, which is more proximal, and the transverse. It arises from the middle of the wrist and hand on the palm side at the capitate, the bases of the second and third metacarpals and the shaft of the third metacarpal. It crosses to the base of the proximal phalanx of the thumb where it inserts with a sesamoid bone, on the ulnar side of the FPB insertion. It adducts the thumb to the hand.

The final group of four muscles, the lumbricals, crosses the hand diagonally from the flexor tendon, FDP, on the palm side, to the extensor muscle expansion on the dorsum. They always cross on the radial side of the finger. Because of their diagonal line of action they can combine the actions of flexing the MCPJ while extending the PIPJ and DIPJ. The 'extension' role is stronger. This posture of combined flexion at the proximal joint of the finger, with extension of the two distal ones, is called the intrinsic position of the hand. It is more or less the same position which is called the **safe** position of the hand.

EXAMINATION

Examination of the proximal forearm, at the elbow, is described in Chapter 7.

The shaft of the radius is covered with muscle for the proximal half of its length and then it is superficial on its palmar, dorsal and radial aspects right down to the wrist.

The ulna is similar to the tibia in having a margin which is superficial from one end to the other. The tibial margin runs from the tibial tuberosity to the medial epicondyle and is well known as 'the shin'. Our ulnar 'shin' is less well known, mainly because it is less visible on the back of the forearm in a deep ridge between the extensor and flexor muscles and also because it is less exposed to painful knocks. You can palpate the whole length of the ulna from olecranon to ulnar styloid process.

There is a prominent longitudinal ridge on the dorsal radius at the wrist named Lister's tubercle, around which tendons pass to the thumb. Palpate towards the ulna from there and you will feel the distal radioulnar joint. This is the ligamentous connection of the two bones of the forearm. There is slight springiness at the joint if the distal ulna is pressed in a dorsal to palmar direction. If the ligament is torn the distal ulna may have an increased dorsal elevation, visible when compared to the patient's other wrist, and it may become more mobile.

In an ulnar direction from there is the rounded bulge of the distal ulna. At its distal inferior tip is the styloid process,

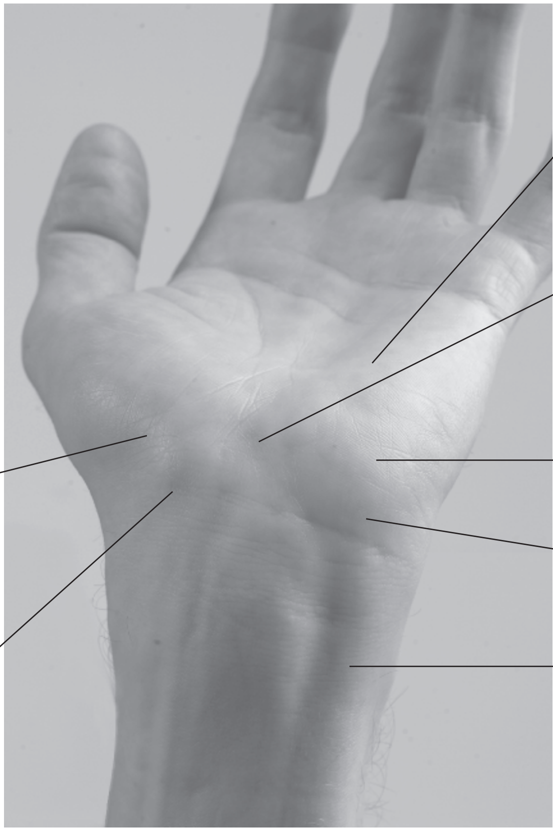


Fig 8.7 Examination of the palmar carpal bones of the wrist.

a small prong which attaches ligaments and which can be fractured.

At the distal end of the radius on the radial border the bone curves softly into a hollow of the carpal wrist which is widely known as the **anatomical snuffbox** (**ASB**). The boundaries of this hollow are tendons of the thumb, and the hollow is increased in depth by lifting the thumb away from the hand.

Ask the patient to hold the hand in a neutral position, not deviated towards the ulna or radius: put your index finger into the ASB and press upwards. The smooth bone which you feel is the styloid process of the radius. Turn your finger downwards towards the thumb. The bony ridge which you meet nearer to the base of the thumb is the trapezium. Hold the hand as if you were shaking hands and move it into ulnar deviation with your fingertip pressed gently into the ASB in an ulnar direction. You will feel the scaphoid move radially to meet your finger. Extend the wrist and feel the ridge of the scaphoid tubercle on the palmar surface with your thumb. Finally, flex the wrist and put your middle finger on the dorsal aspect of the scaphoid. You can now enclose the bone between thumb, index and middle fingers. You will now have a clear sense of the position and contour of the scaphoid and you will be able to decide whether the bone is significantly tender.

Examination of the carpal bones is summarised in Figures 8.5, 8.7 and 8.8.

A detailed description of the muscles of the forearm, wrist and hand, and a method of resisted examination of each of these, is given in Figures 8.9–8.23.

The peripheral nerve distribution is shown for sensory nerves in the hand and for the motor distribution in the forearm, wrist and hand (Figs 8.24–8.29). Resisted tests for the relevant muscles are shown.

Figure 8.30 illustrates the muscle structures which would need to be examined at 20 different injury sites on the hand.

Examination of the hand

The hand differs from the other joints of the limbs in that wounds rather than closed injuries are the commonest cause of grade 3 divisions of ligaments and tendons:

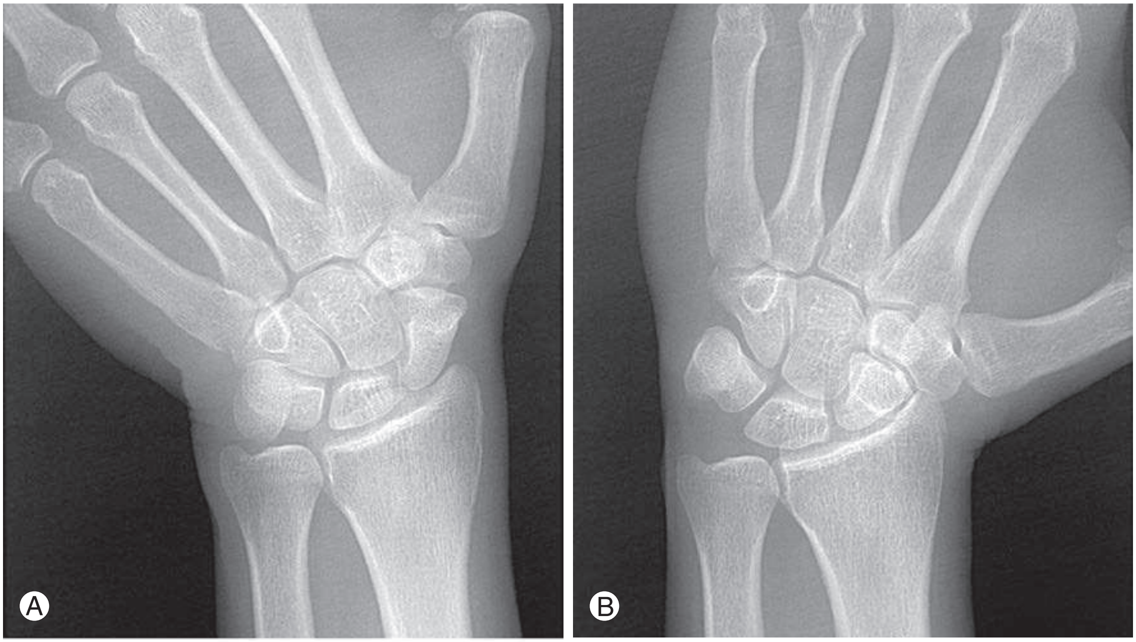


Fig 8.8 Scaphoid X-ray. Image A shows the wrist in ulnar deviation, with the scaphoid palpable in the anatomical snuffbox. B shows the wrist in radial deviation: here the radial styloid meets the trapezium in the snuffbox, and the scaphoid is not palpable. (A and B reproduced with permission from Standring 2008.)

it will be a daily experience for you to combine wound exploration with functional tests of the 'deep structures' around the site of a hand injury. This chapter deals with the examination and diagnosis of closed injuries but that does not imply that these techniques cannot be combined with the exploration of a wound. Wounds are discussed in Chapter 16.

The process of examining the injured hand has the same purpose as any other examination, to reach a diagnosis. The specific concern which arises with the hand more than any other musculoskeletal structure is that it is a complex but finely balanced instrument, containing a large number of important working parts within a small area, all very close to the surface, most of them lying on hard bony surfaces which can serve as chopping blocks or as one of the two hard surfaces which are needed to create a crush injury.

Those parts which we tend to call 'deep structures' in the hand are, in practical clinical terms, parts which would need to be repaired separately from the outer layers of a wound, or which would require specific treatment of some other kind if the injury is closed. In other words, if we fail to diagnose the injury the patient will not receive the treatment he or she needs, and the hand will not work properly in the future.

Box 8.2 lists the main deep structures which are found in the hand and describes assessment of them. You will note that all but one of them is fairly easy to assess. The difficult structure to examine and diagnose is muscle. There are several reasons for this:

- The muscle anatomy of the hand is complicated. It requires a large number of muscles, some traveling a long way because, like commuters into a busy city, there is no room to house all of the workers within the centre. Long tendons lie close to the skin on one side and to the bone on the other and they are easy to injure: they are subject to stress as they travel, the effects of 'wear and tear' and 'overuse'.
- The movements of the hand require coordination, dexterity, precision, sensitivity and power, and the structures which enable that are complex.
- There are considerable variations in what is anatomically and functionally normal from one person to another and it is important when assessing a hand that you compare it to the uninjured one.
- Muscles in the wrist and hand are numerous and travel together for much of their journey. Every muscle acts on every joint that it crosses to a greater or lesser degree and the loss of one muscle at a busy joint may be hard to distinguish because the joint may still be moving. However, with one or two exceptions, each muscle has an indispensable

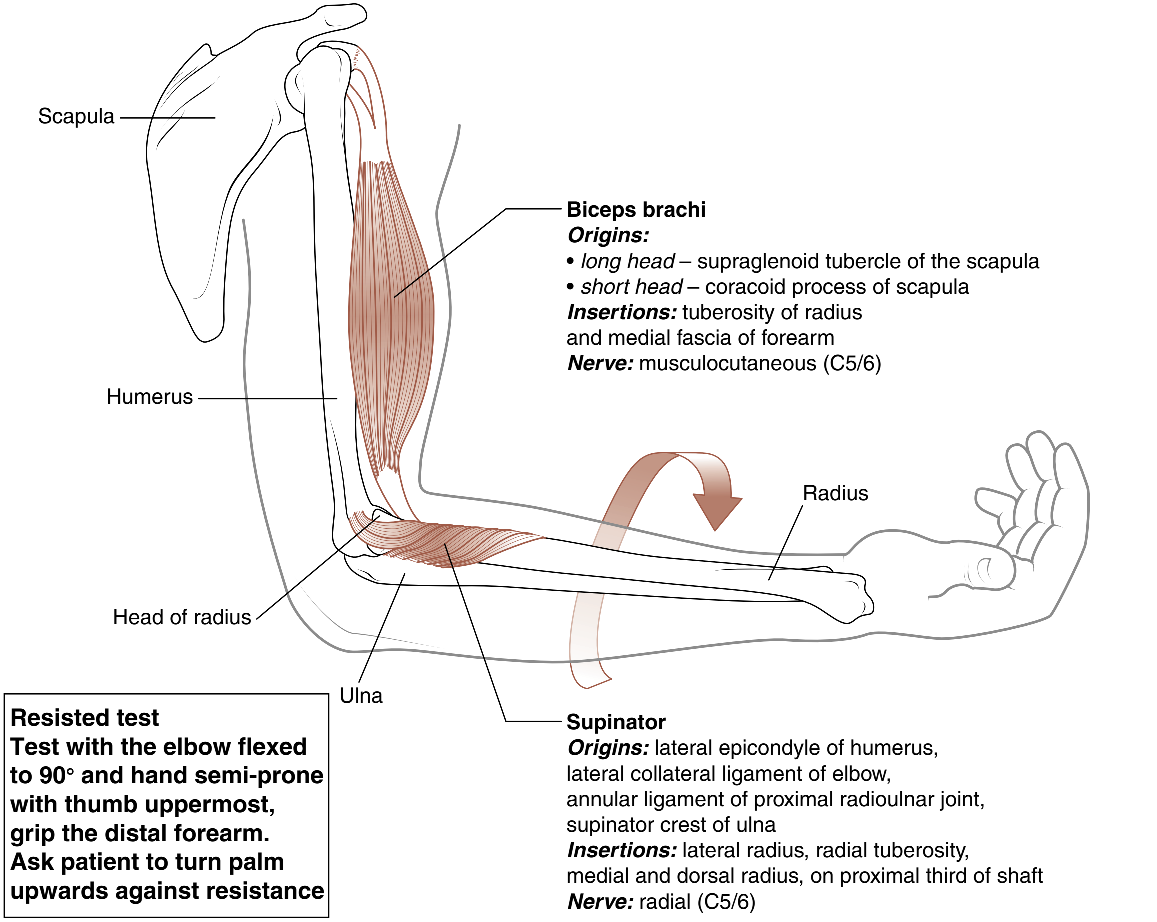


Fig 8.9 Supinators of the forearm.

role and any loss will cause a decline in overall function.

- Injuries to muscles and their tendons can be occult (and a similar problem is often found with sensory nerves in the hand). This means that something is injured but that it is not obvious at once. The hand may, especially to an inexperienced examiner, seem normal. However, for one reason or another, the injury will worsen over time and function will decline. A sting in the tail is that there is often an inverse proportion between the obviousness of the injury and its treatability. Situations where this happens include partial tendon injuries which go on to become complete ruptures; injuries where the loss of one muscle causes a gradual change in the way that others work; and injuries where one muscle performs some of the roles of an injured one and the missing function which would reveal the loss is not picked up on examination. Some injuries cause obvious changes in the normal posture of the hand, while others will only be noticed when specific movements are elicited.
- A full examination to exclude every possible injury cannot always be done, especially if the patient presents immediately after the injury. If an injury is fresh, painful, bruised and swollen, the patient may not be able to perform movements for you even though the muscles are not damaged. There may be another injury, such as a fracture or dislocation, which you manage as a first priority and this prevents you from finding a muscle injury which will cause problems later. For this reason you must know, when you see an injury, the other possible injuries and common complications: advise the patient and arrange such follow-up as he or she needs to deal with that risk.

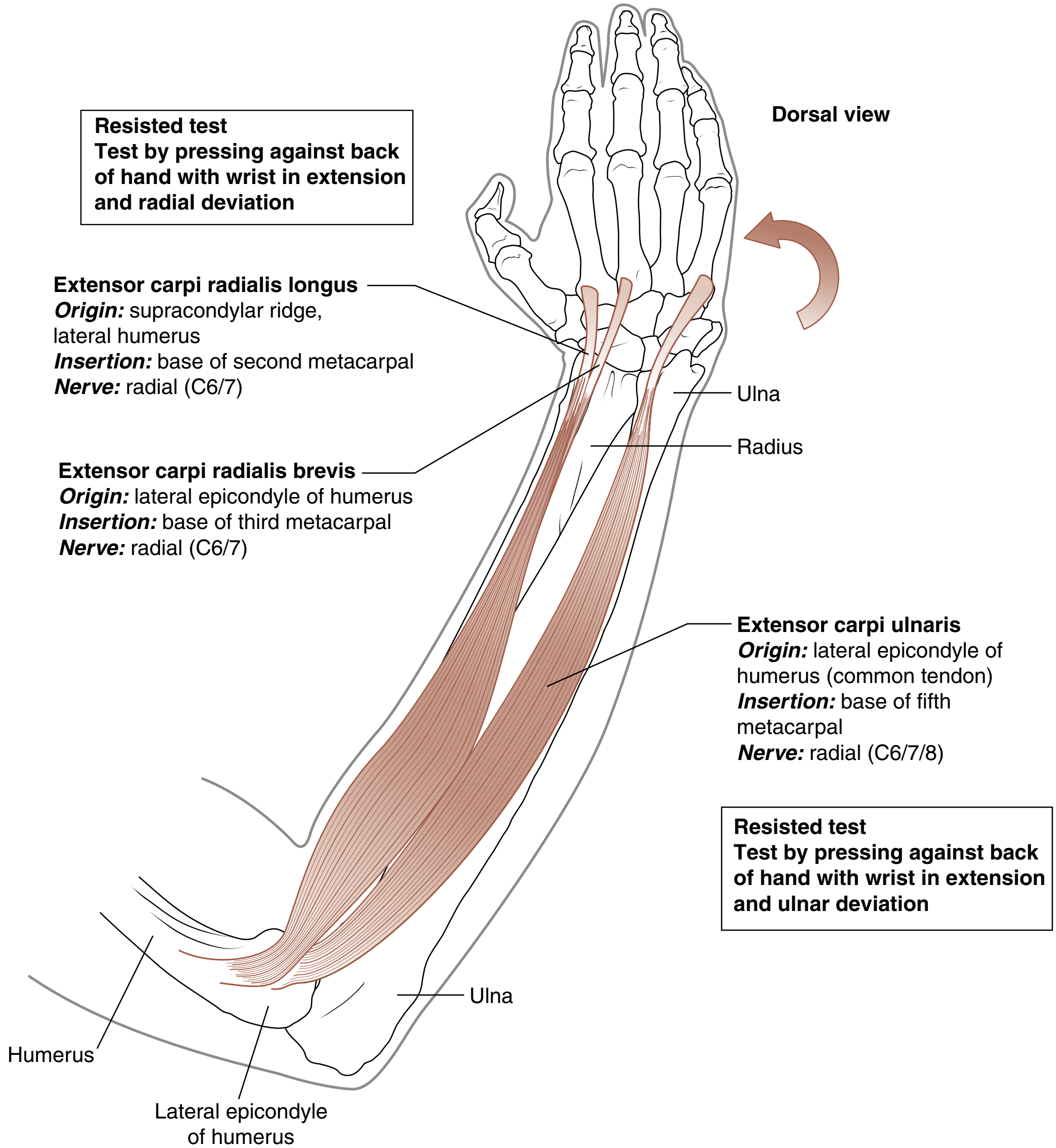


Fig 8.10 Extensors of the wrist.

It is unfortunately the case that even with competent examination an injury will occasionally be missed. Document your examination carefully so that you can demonstrate that you have done everything that is reasonable. If you recognise and cannot eliminate a risk consider the use of imaging, referral and review procedures. Remember also that a few simple words of advice – 'if your finger gets droopy or twisted, don't wait to see if it will get better, come right back' – can make a big difference to outcome.

The illustrations of the hand combine muscle anatomy with basic advice on examination and cover all of the muscles which require testing. More detail on how to test each muscle is given below.

Learn to examine the muscles of the hand as a complete routine, a recitation of an essential alphabet for the diagnosis of patients with minor injuries.

Examination of the hand usually occurs at a table with the patient seated. If the injury involves a wound, or if pain is significant, think about whether the patient should

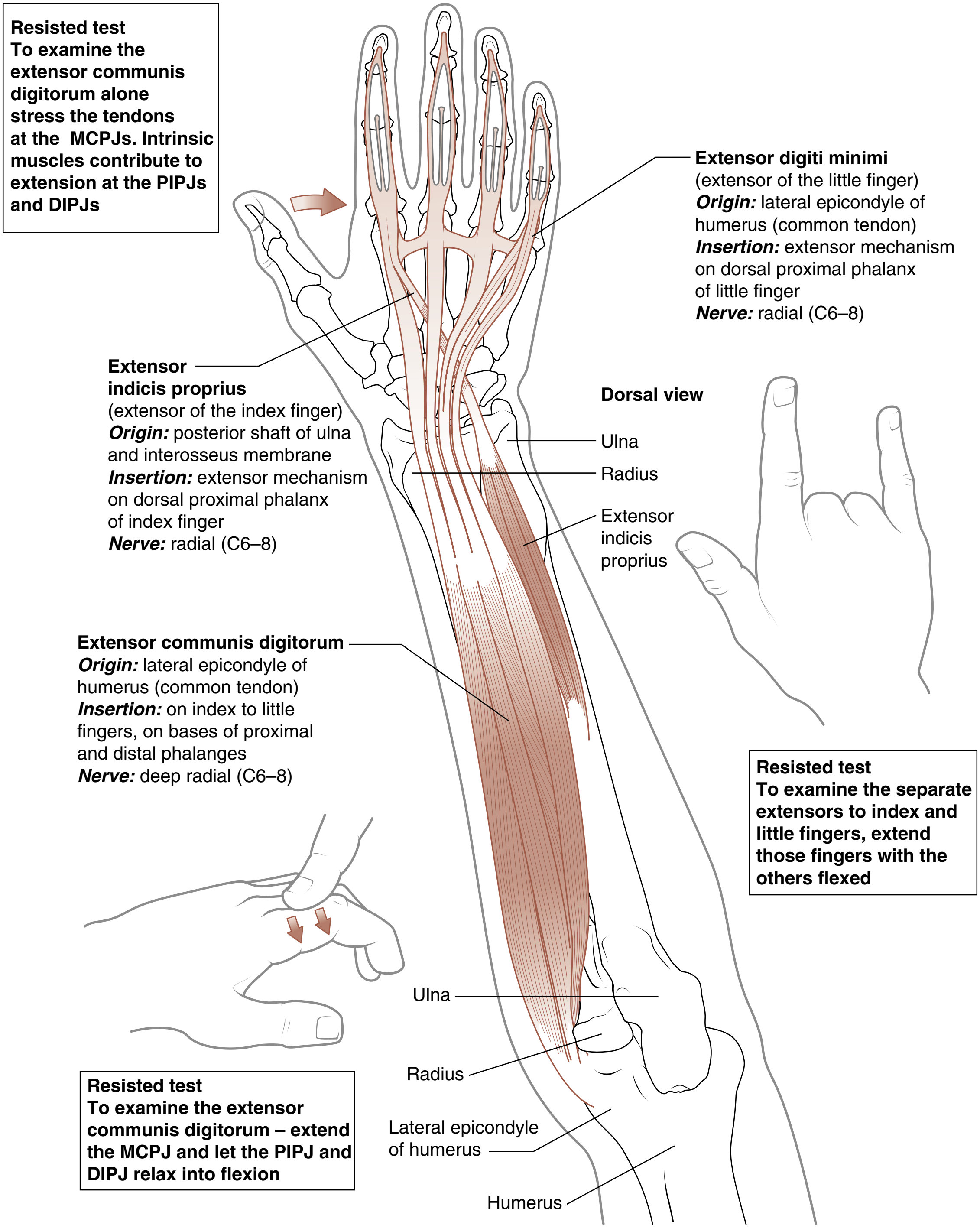


Fig 8.11 Extensors of the fingers.

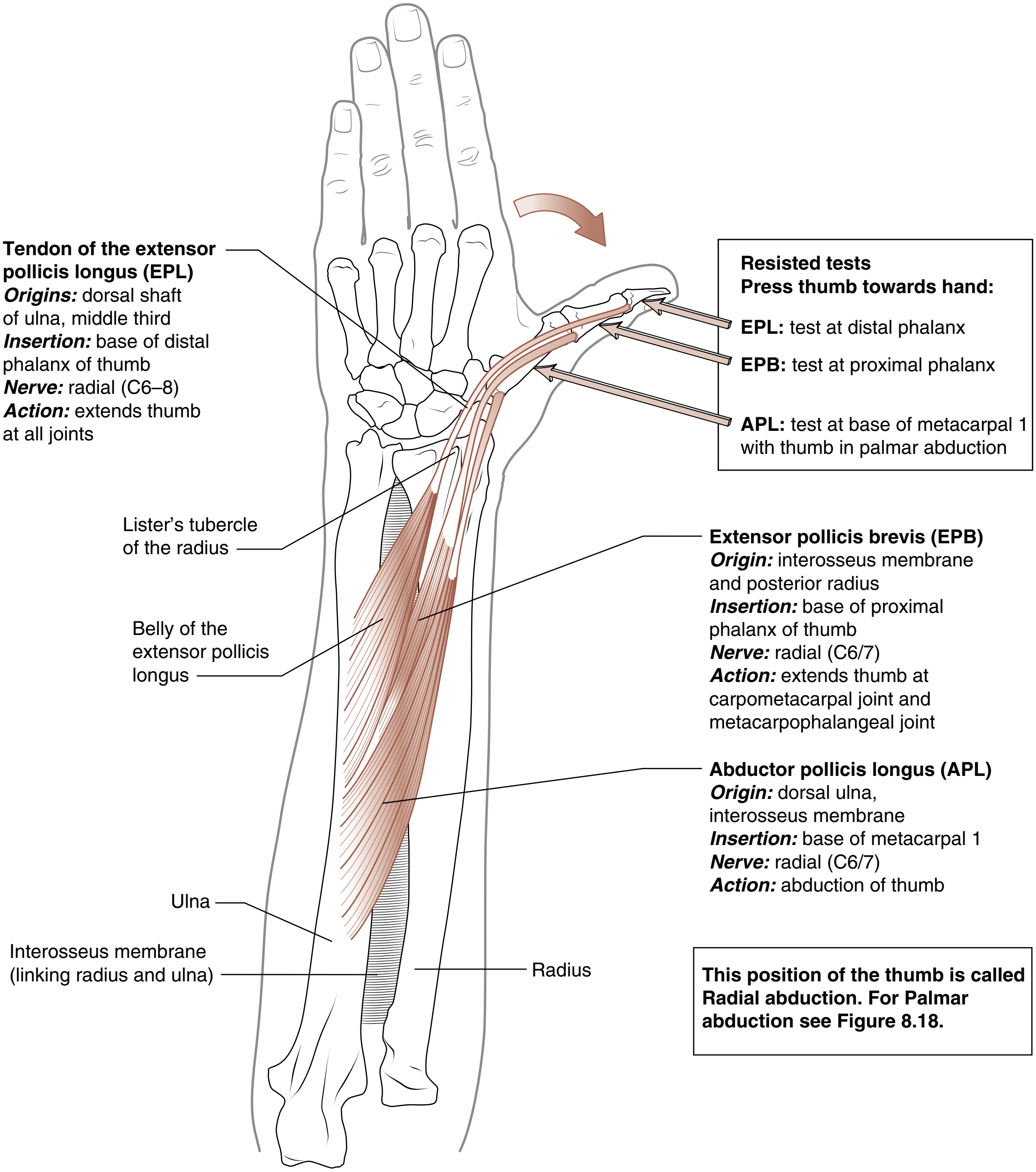


Fig 8.12 Extrinsic abductor and extensors of the thumb.

lie down, and whether analgesia or local anaesthetic are required.

Before giving a local anaesthetic remember two points: complete your assessment of the sensory nerves before you numb the area; when you do a resisted test of a muscle the two signs of injury are pain and weakness. The patient will not feel pain under local anaesthetic, and may not sense that a partially torn tendon is about to tear completely. Therefore the examination would fail to reveal an injury, or reveal it by making it worse. Plan the sequence of your examination.

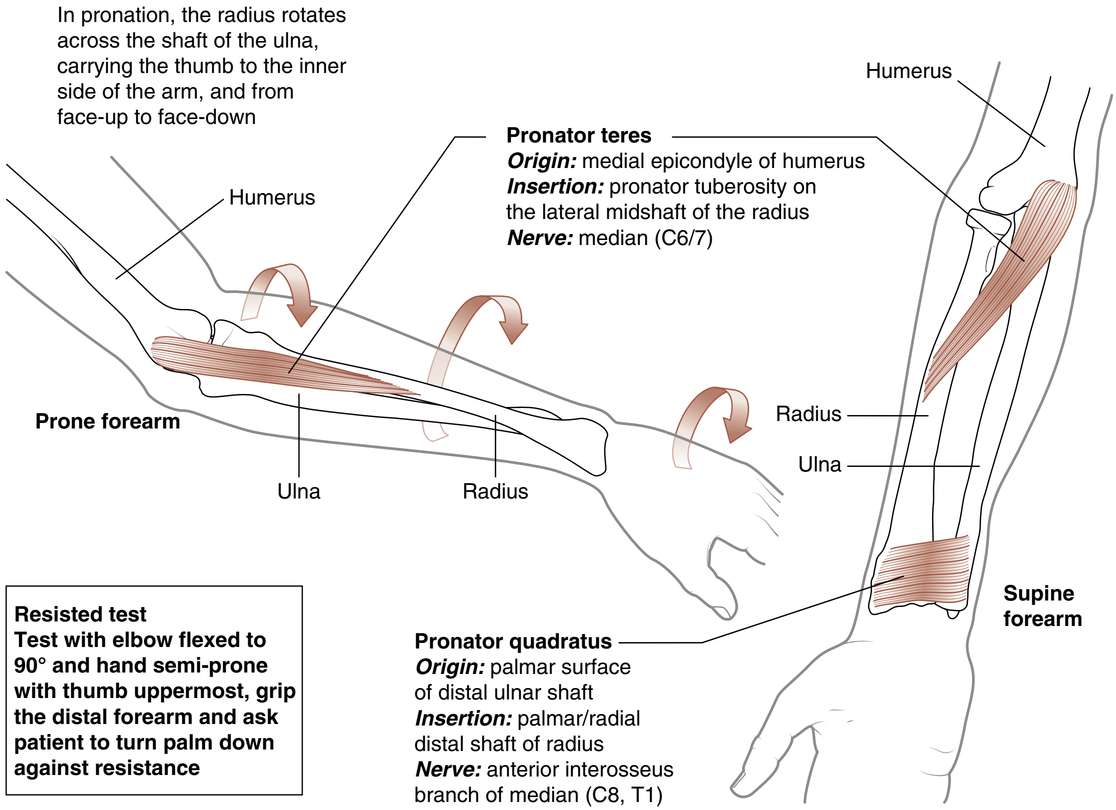


Fig 8.13 Pronators of the forearm.

Look

Observe the relaxed posture of the hand in the supine and prone positions with the hand raised from the table so that it is unsupported. Tendons and muscles have limited length and those that cross more than one joint influence the posture of each joint according to the length and tension in the muscle, and according to the position of the other joints that the muscle crosses. To demonstrate this effect, which is called **tenodesis** (Box 8.3), try to flex your wrist with your elbow fully extended and then compare your range of wrist flexion when you also flex the elbow. In the supine position the wrist extends and the fingers lie in flexion. Each finger is increasingly flexed from index to little in a smooth cascade. The thumb is also slightly flexed at both joints and sits in front of the palm so that its tip is almost touching the distal phalanx of the index finger. In the prone position the wrist flexes and the thumb extends. The fingers also extend, though not quite fully. Some, though not all, complete tendon ruptures may show themselves at this stage in the examination, by a failure of one part of the hand to share in the pattern of the rest or by a completely abnormal posture throughout the whole. For example, an isolated tear of a flexor digitorum profundus muscle may cause one finger to fail to flex at the DIPJ when the hand is supine, an abnormality which will be conspicuous because the other fingers will be flexing in a cascade pattern. If the flexors are completely divided, perhaps at the wrist, all fingers may lie extended when the hand is supine.

Displaced injuries are common in the forearm, wrist and hand. Observe for characteristic changes, including dinner-fork deformity, loss of knuckle definition at the head of the metacarpal of the little finger, rotational deformity of a finger, dislocation of a finger joint and angulation of a fingertip with nail bed injury.

Feel

Ensure that you are able to locate the scaphoid. The bone is not palpable in the anatomical snuffbox except when the wrist moves into ulnar deviation. The bones of the wrist and hand, with the exception of the pisiform and the hook of hamate (the canal of Guyon, where the ulnar nerve passes from wrist to hand at the hypothenar), are best felt on the dorsum. When performing resisted

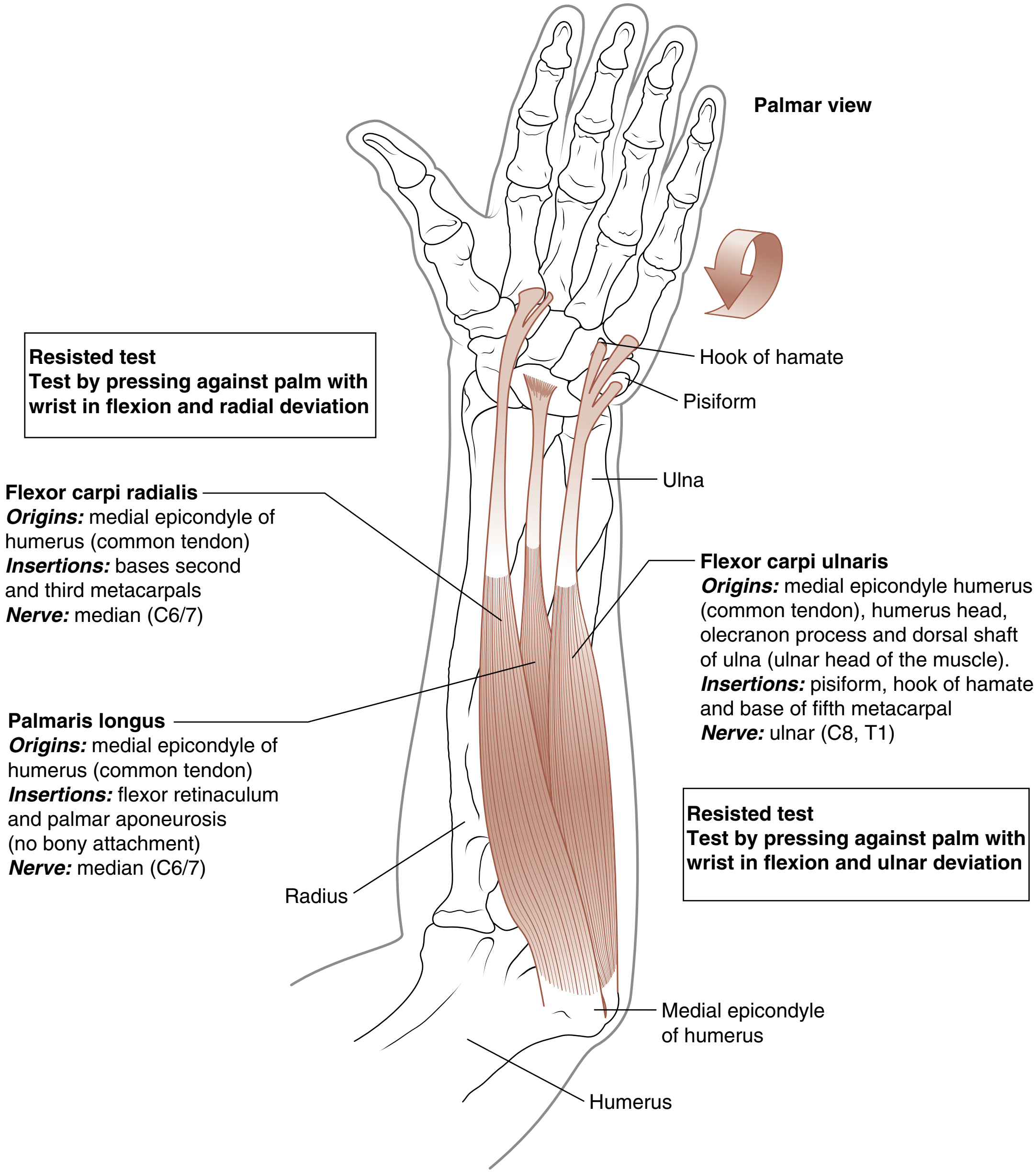


Fig 8.14 The flexors of the wrist.

tests of the muscles of the hand, locate and palpate the muscles.

Move

A routine of examination of the muscles of the hand is described and implicitly recommended here. A progression of tests from distal to proximal will allow you to assess each muscle and then to disable it so that the next one above it can be selected.

When you are testing a muscle use your free hand to support the patient's hand near the joint so that you are certain that only the muscle being tested is working, and so that the patient's hand is comfortable. If it is possible, also place

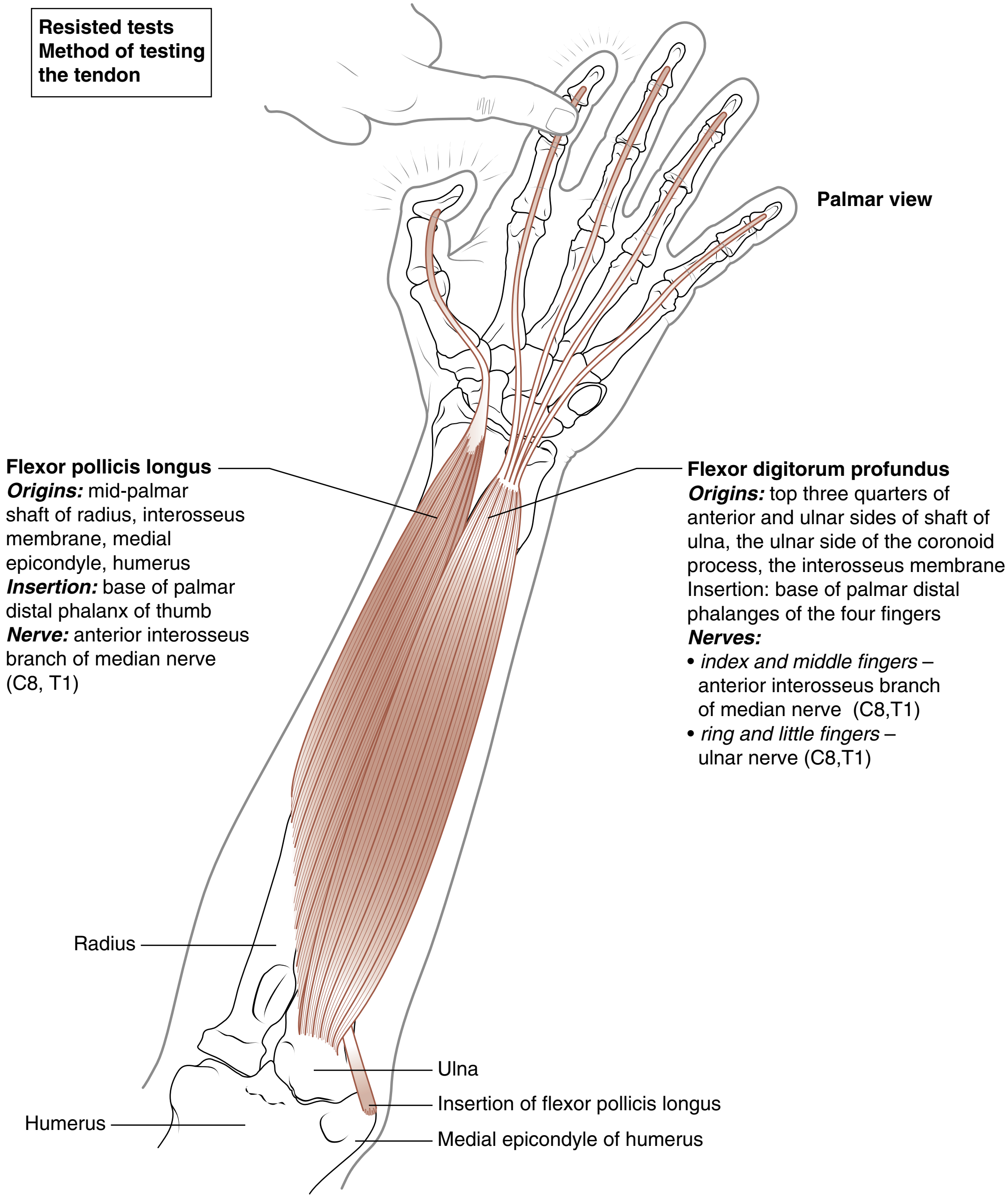


Fig 8.15 Deep flexor of the finger, long flexor of the thumb.

the free hand over the tendon of the muscle being tested so that you can also feel its contraction. If you believe that a tendon may be partly torn then first test the same muscle on the uninjured side to assess the likely power of the injured side, and begin the test very gently. If you meet unexpected weakness, stop the test. It is possible to convert a partial tear into a complete one by the application of sudden force.

The simplest muscles to test are those which lie at the fingertips. This is because the muscles are alone, with no others passing over to a joint beyond. If the end joints can move, you

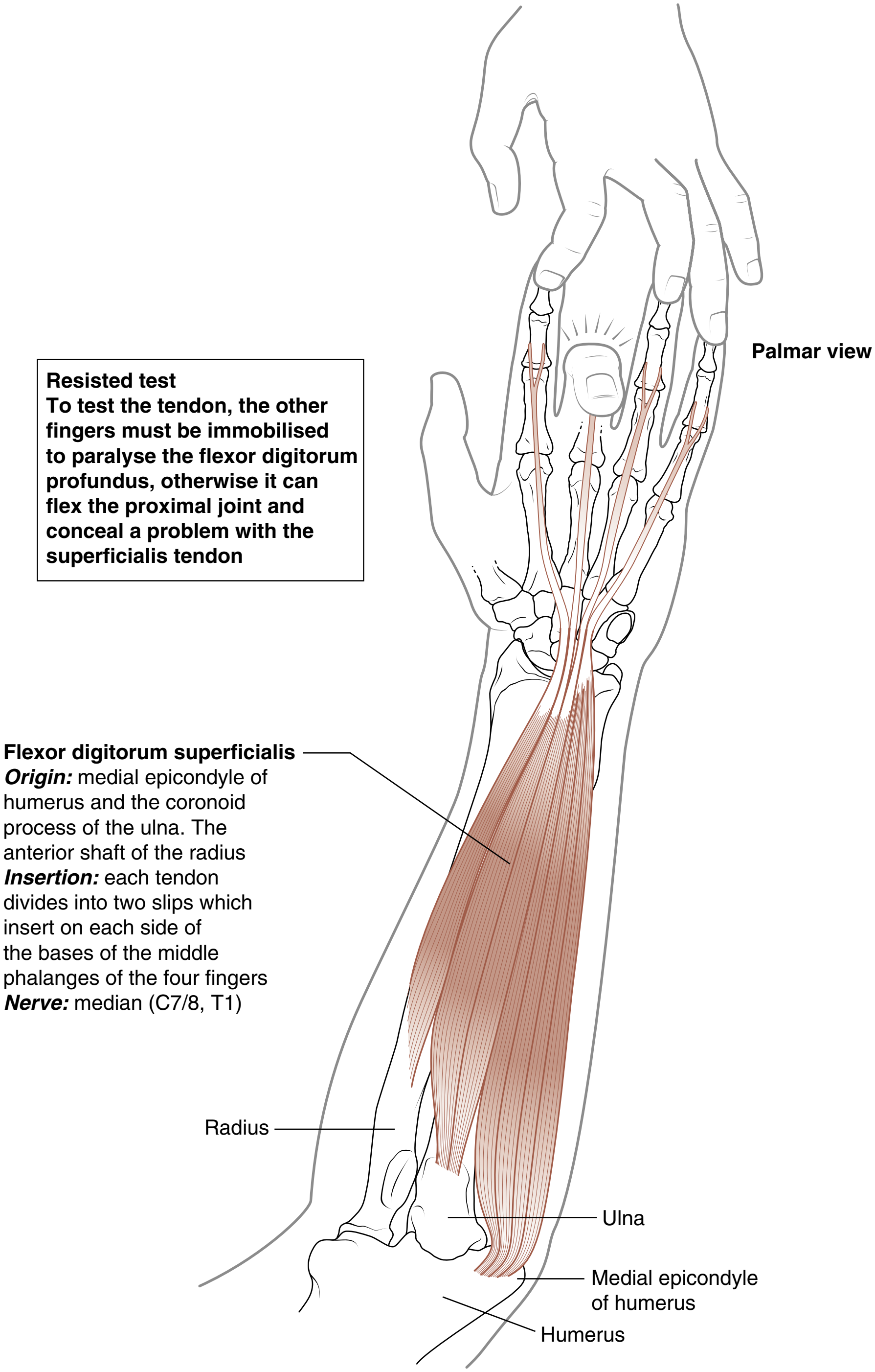


Fig 8.16 Superficial flexor of the fingers.

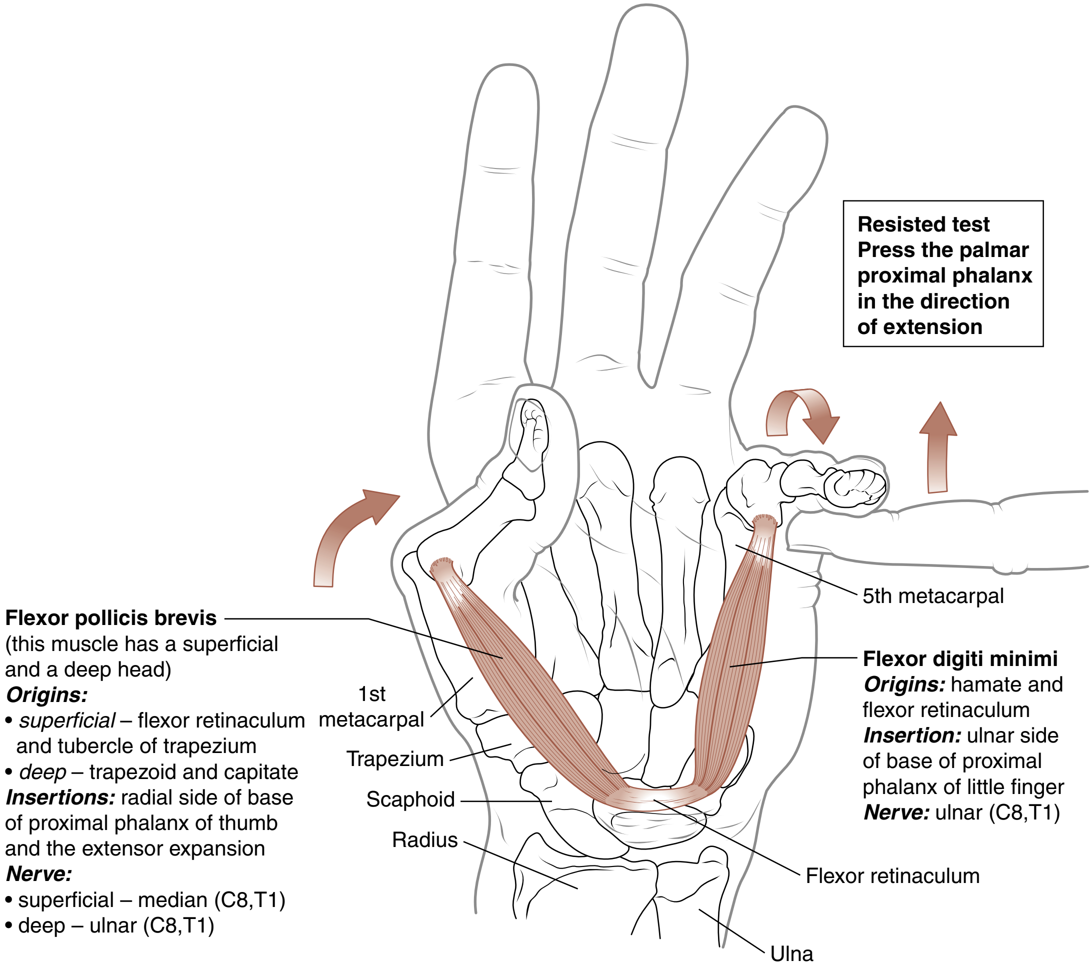


Fig 8.17 The intrinsic flexors.

know which muscles are responsible and you know that they are working. If they offer full power compared to the same muscle on the other hand and they are pain-free, they are unlikely to be injured. It therefore makes sense to start testing from the fingertips and move proximally, immobilising each joint after testing so that the next muscle up has to take over.

For example: on the flexor side, the palm, you will first test the flexor digitorum profundus. With the hand supine ask the patient to bend the index fingertip. Place your finger on the palmar middle phalanx to stabilise and isolate the distal joint of the patient's finger. With the other hand, place a finger on the palmar pad of the patient's distal phalanx and offer gently increasing resistance, saying 'don't let me straighten your fingertip'.

Once you have tested the four tendons of the FDP, one to each finger, you will move proximally to the FDS at the PIPJs of the same fingers. In order to test the FDS you must be clear that the FDP is inactive: if the FDP is active it can flex, not only the DIPJ, but also the PIPJ; and therefore it can mask a deficit in FDS. If a patient can only bend the PIPJ after bending the DIPJ, able to thread a needle but not to hold a pen, then FDS is not working.

The common method of eliminating the FDP for a test of FDS is to test one finger and hold the other three flat upon the table. Because FDP is a single muscle with four tendons, the fingers are obliged to move together. If three fingers are held down, the fourth one cannot flex at the DIPJ. This allows FDS to come into play at the PIPJ. This is one technique which illustrates the single most important principle for examination of the muscles of the hand and wrist. The underlying rule is: test a flexor and then, when you move up to the next muscle, leave

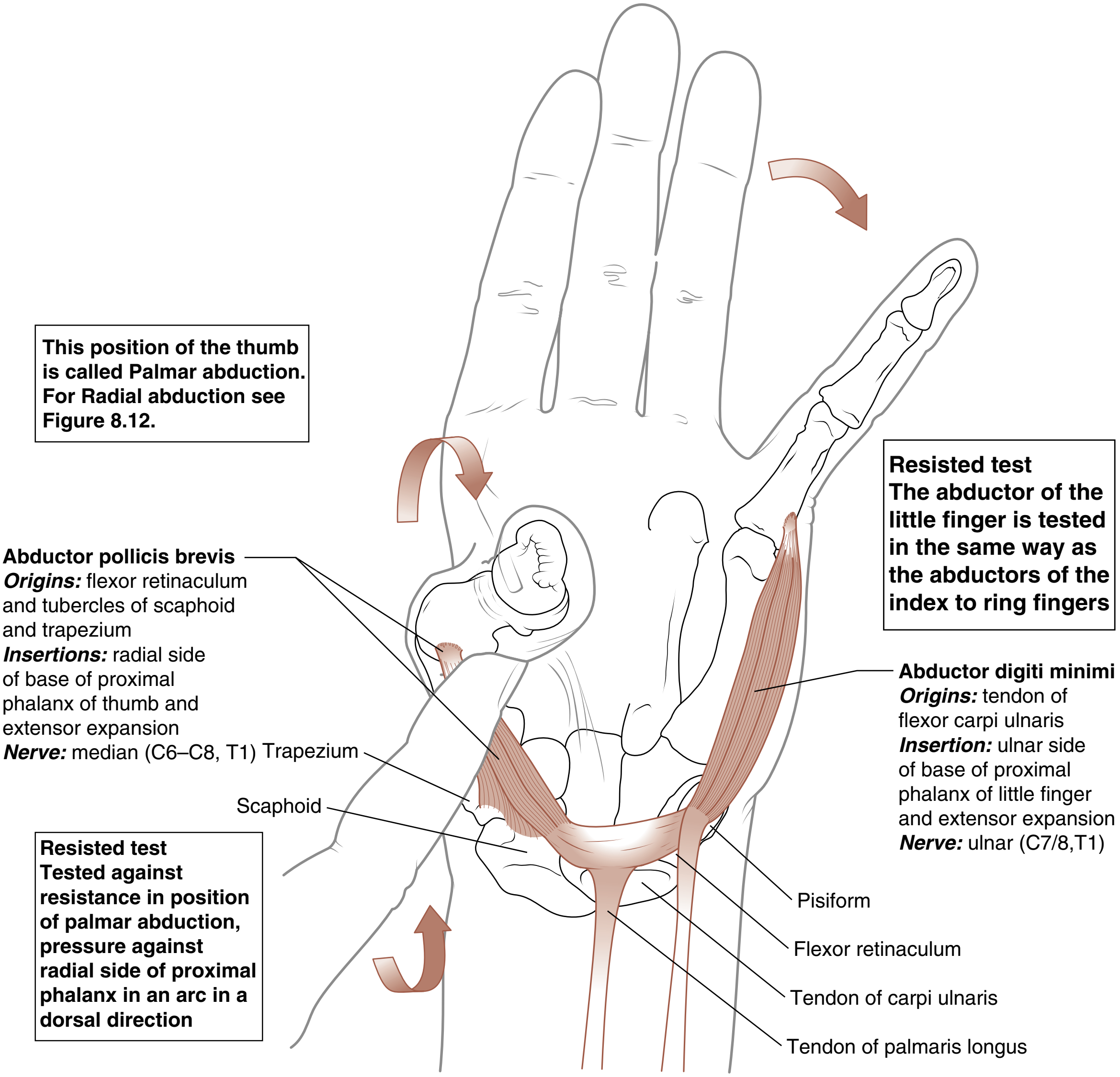


Fig 8.18 The intrinsic abductors.

the first one in extension; when you have tested an extensor, the same principle requires that you leave it in flexion when you move up to the next, more proximal joint. Thus, in the thumb, test extensor pollicis longus with the IPJ extended; then flex the IPJ and test the extended MCPJ for extensor pollicis brevis action; finally, leave the IPJ and MCPJ in flexion and test the abductor pollicis longus with that joint held abducted in a radial direction from the wrist.

The suggested progression of testing, details of which are also illustrated, is as follows:

- Flexor digitorum profundus: palm-up, flex each of the patient's DIPJs, index to little finger, one after the other. Immobilise each one successively by holding it down on the palmar middle phalanx near the DIPJ and put your free hand's fingertip to the patient's palmar fingertip. Say 'don't let me straighten your finger'.
- Flexor digitorum superficialis: hold the tips of each finger down, with the hand palm up, except the one being tested. Ask the patient to flex the tested one. It should flex at the PIPJ, and the DIPJ should

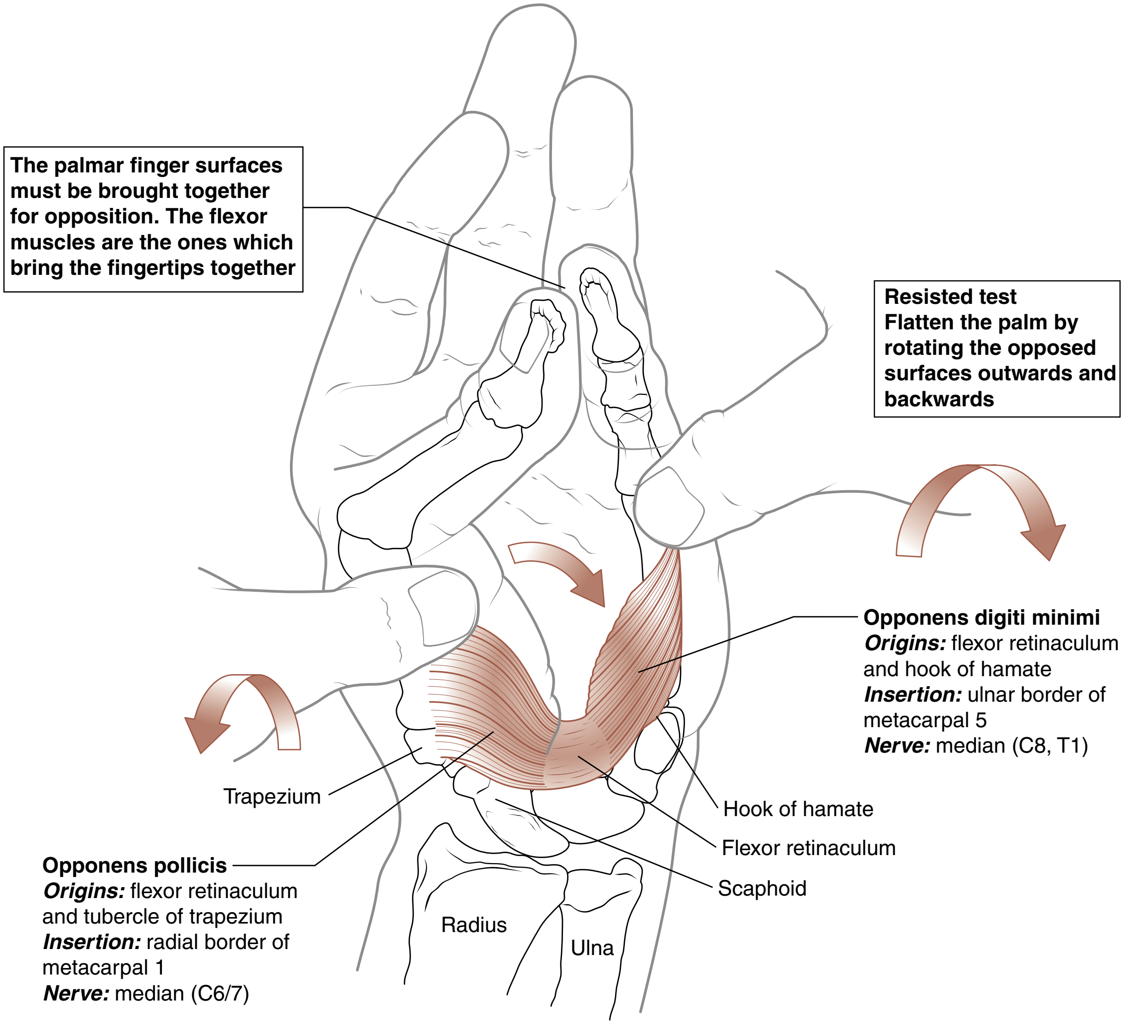


Fig 8.19 The muscles of opposition.

be floppily extended. 'Don't let me straighten your finger'. Repeat the resisted test as above to each finger.

- Flexor pollicis longus: ask the patient to flex the IPJ of the thumb (as if clicking on a ballpoint pen). Support the proximal phalanx to isolate the IPJ and offer resistance on the palm side of the distal phalanx. 'Don't let me straighten the tip of your thumb'.
- Flexor carpi radialis and flexor carpi ulnaris: disable the flexors of the hand by asking the patient to extend fingers and thumb and then to flex the wrist. Press the hand diagonally into extension and ulnar deviation saying 'don't let me straighten your wrist' (FCR). Repeat in the diagonal of extension and radial deviation for FCU.
- Interosseous and lumbrical muscles: ask the patient to turn the hand palm down and hold it above the table with the fingers held straight. Do the 'flick test' of each fingertip, put your index finger under the DIPJ and use the thumb to flick the distal phalanx into flexion. If it springs back, the distal extensor tendons, a combination of interosseous and lumbrical muscles at the dorsal bases of the distal phalanges, are intact.
- Extensor digitorum communis: ask the patient to hold the hand above the table and form a claw-hand, palm down. You would normally expect to test this muscle at the dorsal PIPJ, where it is inserted, but it shares that joint with interosseous and lumbrical extensor tendons and it is not

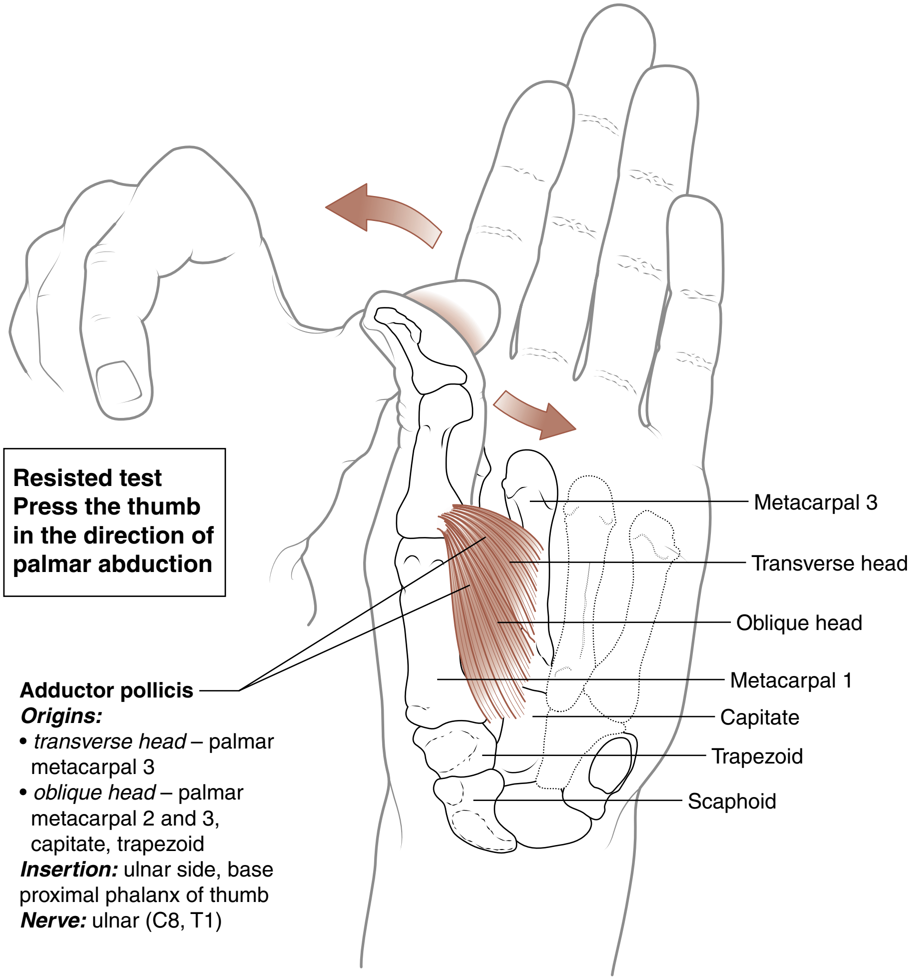


Fig 8.20 The adductor of the thumb.

certain that you can isolate it. You will therefore test it at the joint above, the MCPJ, where it is the only extensor. Press each finger except the thumb at the dorsal base of the proximal phalanx while supporting the MCPJ with the other hand, saying 'don't let me bend your finger'. EDC is superficial and you will usually see the effects of the muscle contraction on the tendons.

- Extensor indicis proprius and extensor digiti minimi: ask the patient to make a fist, palm down, hand above the table. Stick out the index finger on its own. Press the dorsal base of the proximal phalanx (EIP). Repeat with the little finger (EDM). ('Don't let me bend your finger'.)
- Extensor pollicis longus: EPL not only extends the IPJ of the thumb, it also lifts the whole thumb behind the plane of the hand; it is tested in this position. Ask the patient to lift the fully extended thumb behind the hand. Support the IPJ with a finger at the palmar side of the joint and press the thumbnail with the other hand. ('Don't let me bend the end of your thumb'.)
- Extensor pollicis brevis: ask the patient to move the thumb in front of the palm to relax the EPL and to flex the IPJ to disable it completely. Keep the rest of the thumb extended in palmar abduction. Put one finger at the palmar MCPJ to support the joint. Press the dorsal base of the proximal phalanx with the other hand. ('Don't let me bend your thumb'.)
- Abductor pollicis longus: bring the thumb into radial abduction and ask the patient to flex the IPJ and the MCPJ to eliminate EPL and EPB. Press the

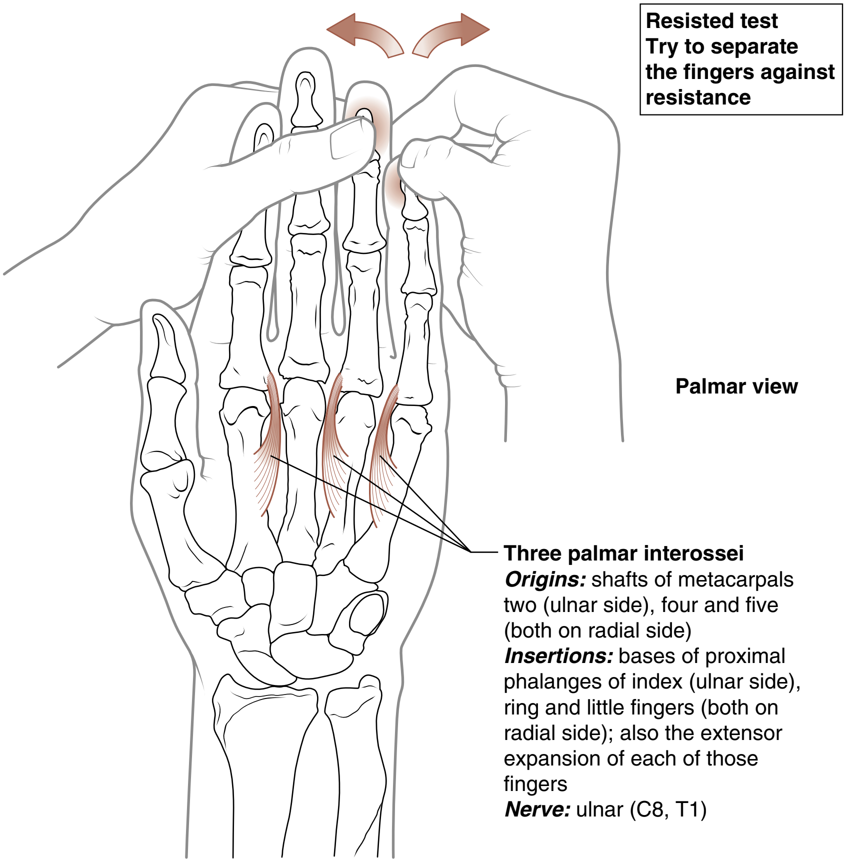


Fig 8.21 The palmar interossei.

radial side of the first metacarpal towards the hand. ('Don't let me press your thumb towards your hand'.)

- Extensor carpi radialis and extensor carpi ulnaris: with the hand palm down on the table ask the patient to make a loose fist to disable the extensors in the hand and bend the wrist back into extension. Press your hand on the back of the patient's hand diagonally in the direction of flexion and ulnar deviation to test ECR. ('Don't let me straighten your wrist'.) Repeat the test on the opposite side, pressing the hand diagonally in the direction of flexion and radial deviation to test ECU.
- Intrinsic abductors and adductors of the thumb and fingers, comprising thenar, hypothenar, palmar and dorsal interosseous muscles: ask the patient to spread all of the fingers apart, palm down and hold them firm against pressure. Press the radial and ulnar sides of each proximal phalanx except the thumb (PIs and DIs). ('Don't let me move your finger'.) Turn the palm up, ask the patient to lift the thumb away from the palm in line with his or her index finger. Press the thumb on the radial side of MC1 towards the palm (APB) and then away from the palm against resistance (AP). ('Don't let me press your thumb towards/away from your hand'.)
- Flexor pollicis brevis and flexor digiti minimi: ask the patient to flex the MCPJ of the thumb while keeping the IPJ extended (FPB). Try to straighten the thumb by pressing on the palmar proximal phalanx while supporting the MCPJ with your other hand ('Don't let me straighten your thumb'.) Ask the patient to flex the MCPJ of the little finger while keeping the DIPJ and the PIPJ extended (FDM). Try to straighten the little finger by pressing on the palmar proximal phalanx. ('Don't let me straighten your little finger'.)
- Opponens pollicis and opponens digiti minimi: ask the patient to put the palmar surfaces of the distal phalanges of the thumb and little fingers

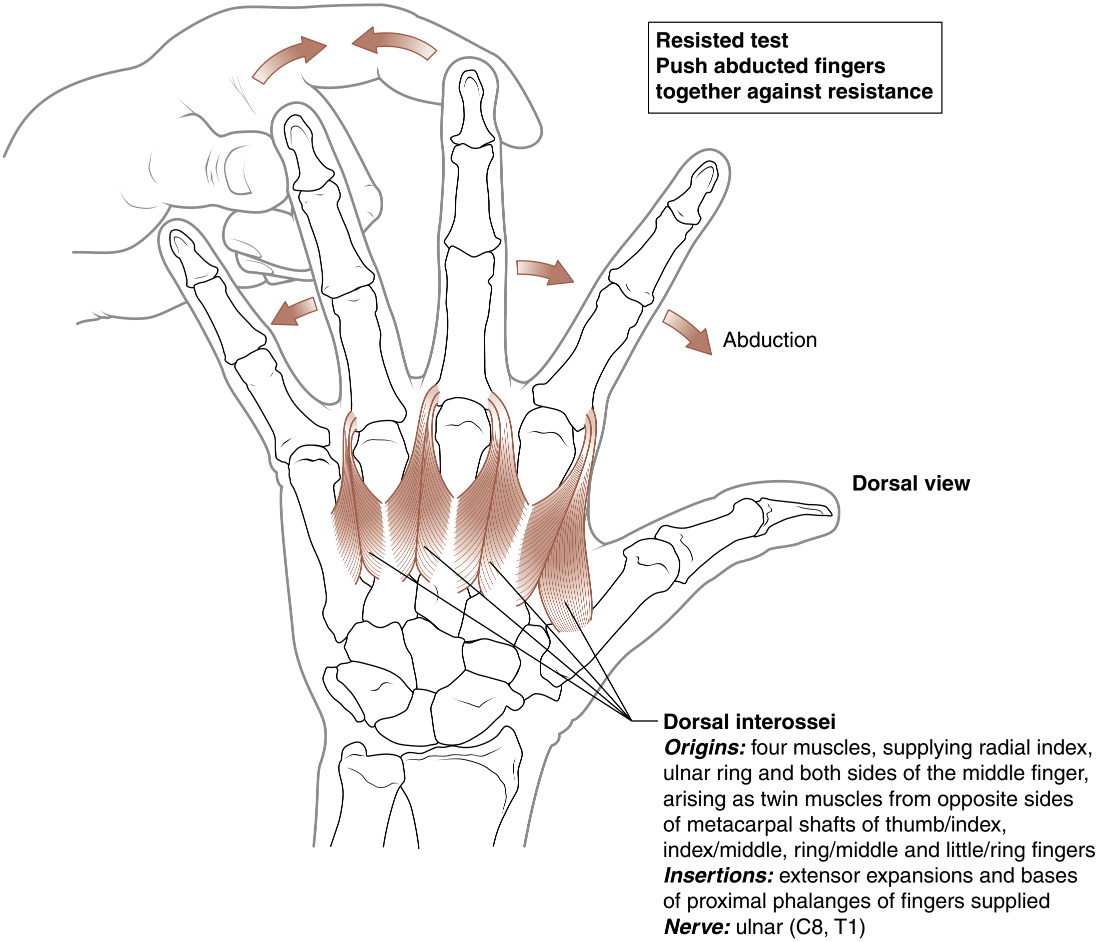


Fig 8.22 The dorsal interossei.

together firmly. Put your thumbs into his or her palm and try to force the opposed digits apart with an unrolling motion. ('Don't let me separate your fingers'.)

X-RAYS

In a minor injury unit or an emergency department the range of standard X-rays for structures below the elbow is:

- **Forearm** (Fig. 8.31): anteroposterior and lateral views of the supine forearm from below the radiological elbow to above the wrist. Do not request forearm views because the patient is symptomatic at both elbow and wrist, you require the individual views for each area.
- **Wrist** (Fig. 8.32): posteroanterior (PA) and lateral views of the distal forearm, carpal bones and the proximal half of the metacarpals.
- **Scaphoid** (Fig. 8.33): a sequence of four views including ulnar deviation, which shows the full length and most of the outline of the bone.
- **Hand** (Fig. 8.34): a PA view shows the distal forearm, carpals, metacarpals and fingers (with a slightly oblique view of the thumb). The metacarpals and the bases of the proximal phalanges of the fingers overlap on a lateral view and an oblique view is given instead for the second image. The lateral view is sometimes given to show a dislocation of a metacarpal base, or the extent of angulation of a fracture of a metacarpal. It is wise to request the lateral view if the patient is tender at the base of a metacarpal between the index and little fingers.

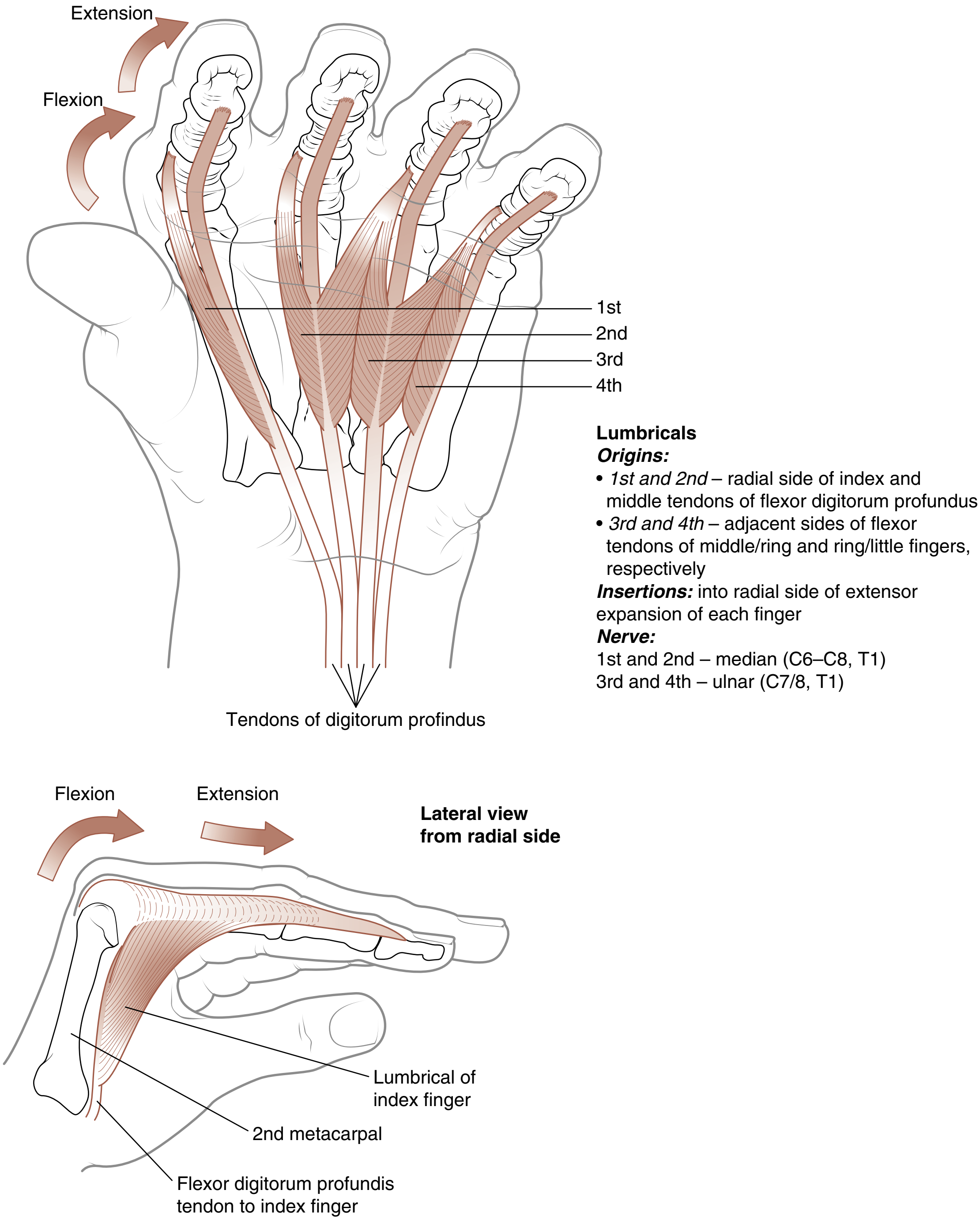


Fig 8.23 The lumbricals.

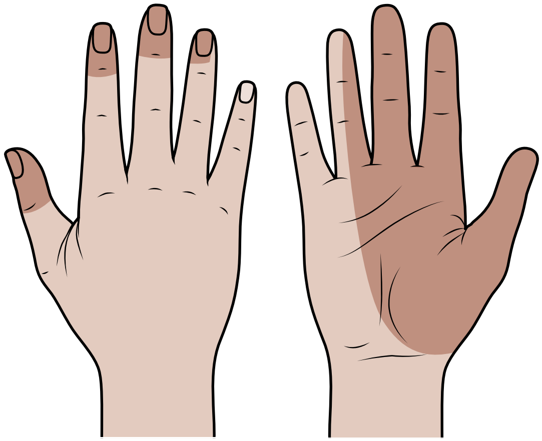


Fig 8.24 The cutaneous distribution of the median nerve on the front and back of the hand.

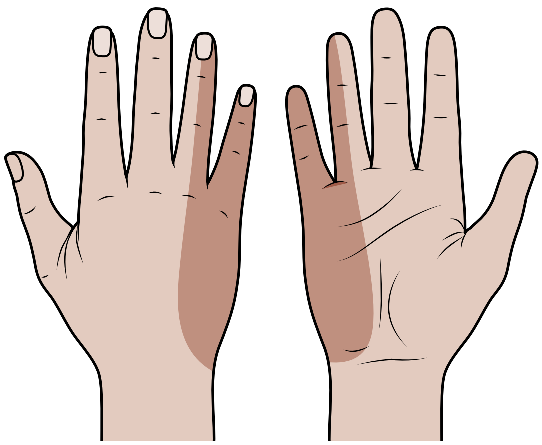


Fig 8.25 The cutaneous distribution of the ulnar nerve on the front and back of the hand.

- **Thumb** (Fig. 8.35): a PA and lateral view shows the thumb from the base of its metacarpal distally. Do not attempt to diagnose the thumb from hand, wrist or scaphoid views.
- **Fingers** (Fig. 8.36): a lateral view of individual fingers (in addition to the PA view) is useful beyond the point where they overlap at the MCPJs. A volar plate avulsion fracture, a common injury at the PIPJ, will be missed if you request hand X-rays.

Wrist X-rays

The carpal bones lie in two transverse rows and have been described in detail above. On the PA view irregular but complementary shapes are separated by a narrow joint space (usually not more than 2 mm) which remains uniform throughout the whole group. The distal radius articulates closely with the carpal bones but there is a space between the carpal bones on the ulnar side (the lunate and the triquetrum) and the distal ulna. This space is occupied by the ulnar triangular fibrocartilage and ligament structure: this structure supports the distal radioulnar joint. Widening of a space between carpal bones on the PA view is usually a sign of injury to a carpal ligament structure. Carpal dislocations are unusual and the lunate is the main offender, an injury which is usually diagnosed on the lateral wrist view.

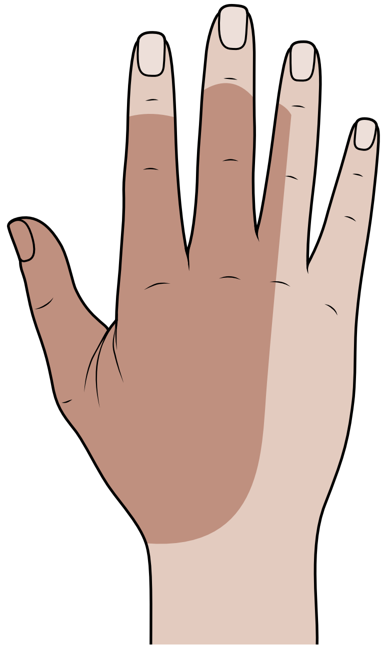


Fig 8.26 The cutaneous distribution of the superficial branch of the radial nerve on the back of the hand.

The styloid process of the distal radius on the PA view extends to a higher point on the image than the ulnar styloid (we usually look at the image with the fingers pointing upwards rather than in the anatomical position) and the distal border of the radius is usually higher than that of the distal ulna.

The lateral wrist view is highly overlapped but certain features can be assessed:

- The cortex of the posterior radius is smooth: otherwise subtle fractures will often cause a slight step, splinter or bulge in this area.
- The posterior lip of the distal radius is higher on the image than the anterior lip, so that the carpal bones appear to lie on a slope towards the palm of slightly more than 10 degrees. A fall on the hand,

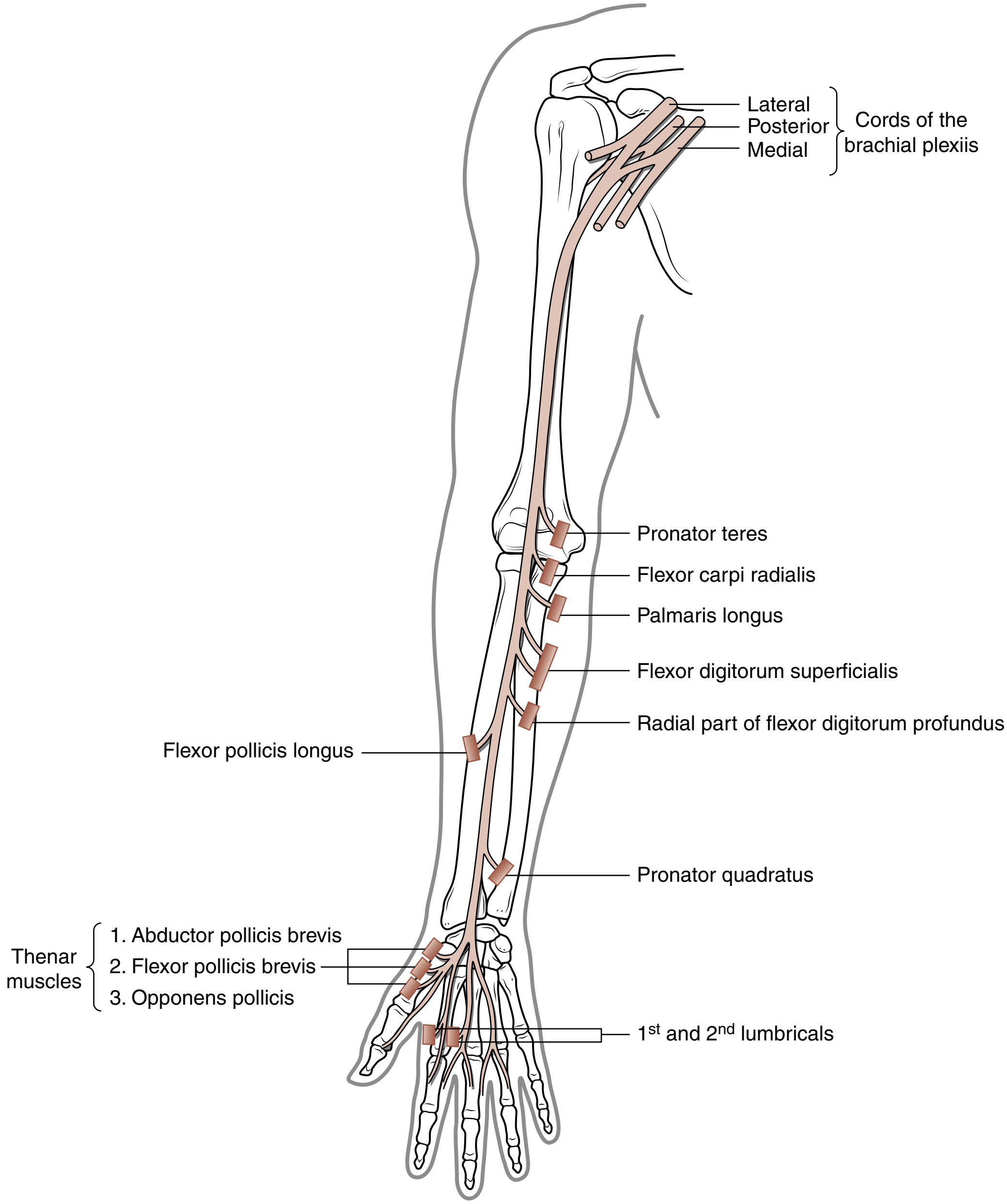


Fig 8.27 The course and distribution of the median nerve in the arm and hand motor supply.

especially in the older patient, may cause a fracture of the distal radius with backward displacement of the distal fragment, a Colles fracture (Fig. 8.37A). This will cause the angle between the posterior lip of the radius and the anterior lip to flatten out and even to reverse, so that the anterior lip is higher on the image. This deformity will have a net impact on the patient's ability to flex the wrist and the extent of the change, measured in degrees of dorsal angulation, will be a factor in the decision whether or not to manipulate or operate upon the injury.

- There is a continuous flow of articulations upwards on the image from the carpal surface of the radius to the lunate and from the lunate to the capitate.

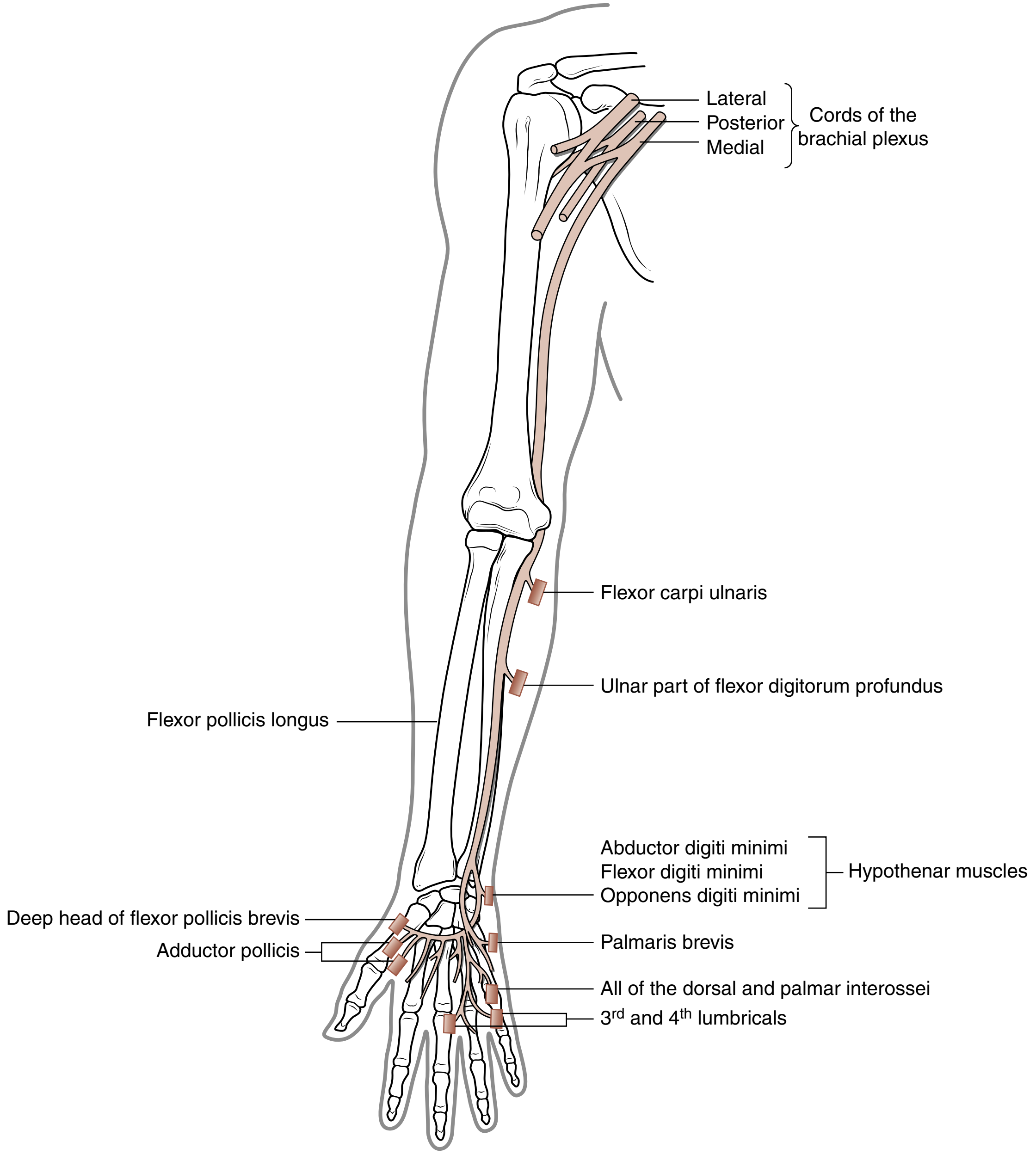


Fig 8.28 The course and distribution of the ulnar nerve in the arm and hand motor supply.

This alignment is described as a 'cup, saucer and apple' arrangement and it is important on the lateral view to see that this arrangement is in place. Dislocation of the lunate, which occurs in an anterior direction, will displace the 'cup' from the sequence.

- Scaphoid fracture is by far the commonest carpal injury, but patients who fall on the hand may present with tenderness over the dorsal triquetrum (just distal to the ulnar styloid). In that case the only radiological sign of a fracture may be a small fragment of broken bone seen on the image of

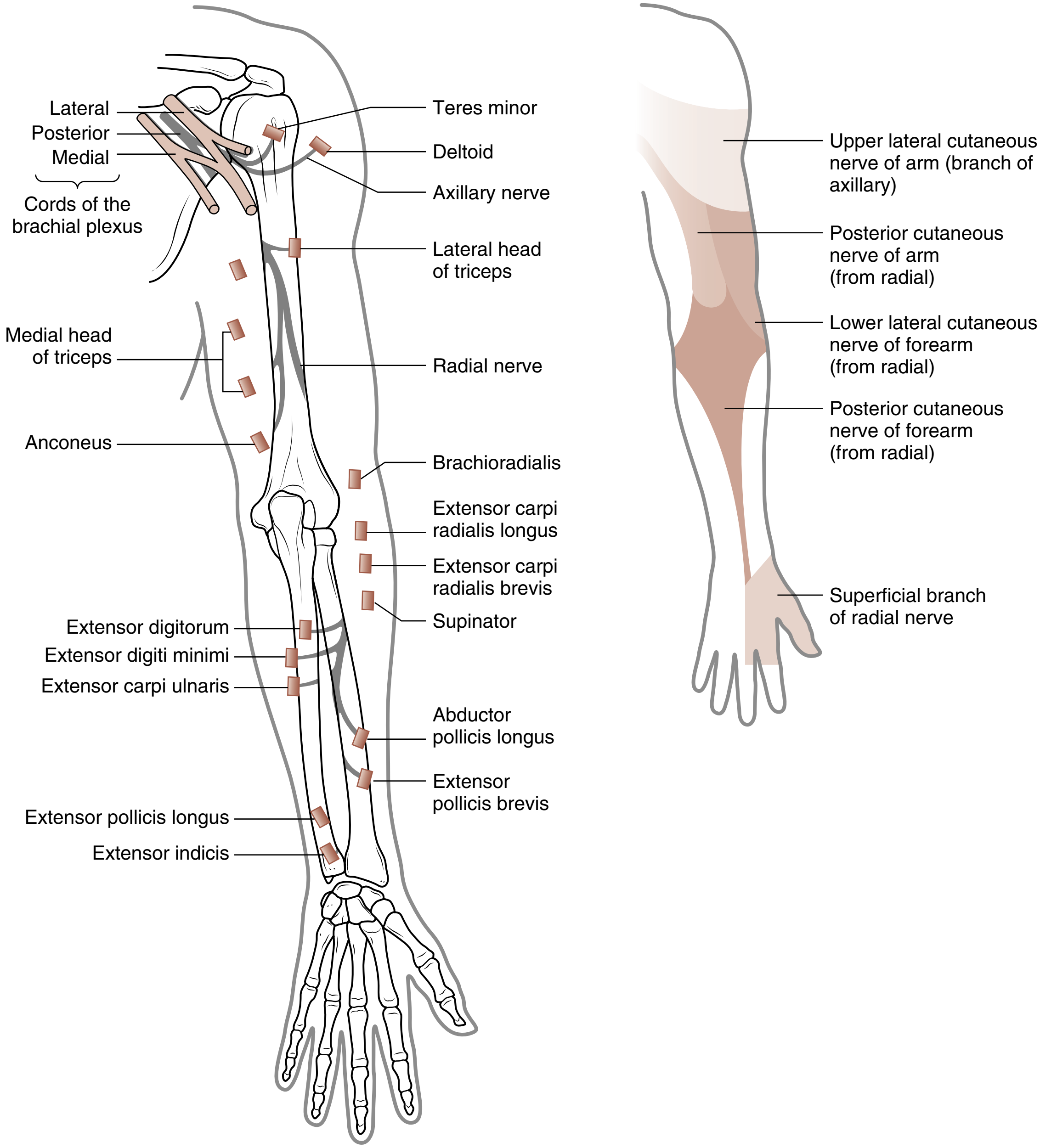
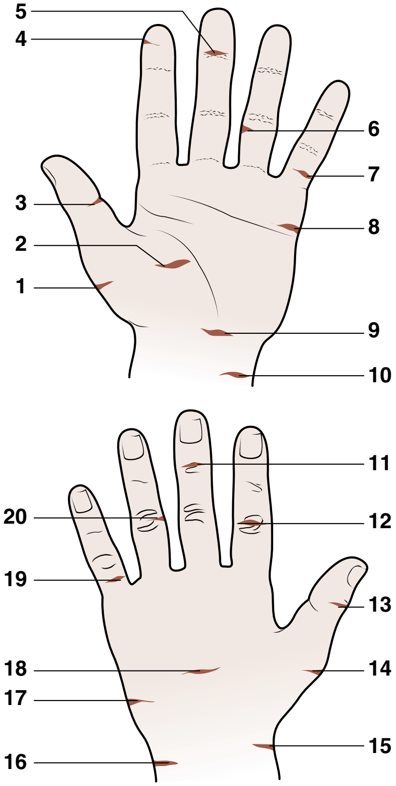


Fig 8.29 The course and distribution of the radial nerve in the palmar aspect of right arm motor supply.

the lateral wrist at the posterior carpal area. On occasion a patient may present with an injury which appears to be mainly to the hand, rather than to the wrist, but with triquetrum tenderness. Hand views alone may fail to show a fracture of the triquetrum.

Scaphoid X-rays

The scaphoid is assessed clinically and, although there are a variety of ways to decide whether there may be signs of fracture, if the zone known as the 'anatomical snuffbox' is tender when the wrist is examined in ulnar deviation,



Key
1. EPB, EPL
2. FPL, FDS and FDP of index and middle fingers, FPB, OP, AP
3. FPL
4. NIL
5. FDP
6. Radial insertion FDS, intrinsic extensor expansion
7. FDS, FDP
8. FDM, ADM, FDS, FDP
9. Carpal tunnel, containing FDS, FDP, FPL
10. FCU, FDS, FDP, PL
11. Distal extensor insertion
12. EDC, EIP
13. EPL
14. EPB, EPL
15. APB, EPB, EPL, ECRL, ECRB
16. ECU, FCU
17. ADM
18. EDC, EIP, EDM
19. EDC, EDM
20. Radial insertion FDS, intrinsic extensor expansion

Fig 8.30 The muscle structures which would need to be examined at different injury sites on the hand.

scaphoid X-rays will usually be requested (see Fig. 8.33). These are views of the wrist area, modified to optimise our sight of the scaphoid, usually a sequence of four images. The scaphoid may have a fracture which does not show on initial X-ray, and therefore, regardless of the X-ray finding, the patient's wrist will be immobilised in a cast or splint, and further images will be taken when signs of fracture healing may be expected to show. The high level of concern which is attached to these injuries arises from the fact that some individuals may suffer avascular necrosis of the bone, with arthritis and a need for subsequent bone graft surgery, if a scaphoid fracture does not heal well. Policies vary in different hospitals for the management of this risk-laden injury and there is an increasing tendency to opt for an early magnetic resonance imaging (MRI) scan of 'clinical' scaphoid fractures. Follow your own department's policies with care. A fracture across the middle of the scaphoid is known as a fracture of the 'waist'.

Ossification of the carpal bones through childhood occurs at a variable pace but it can be said as a generalisation that the scaphoid will not have matured sufficiently to justify a request for X-rays of that bone before the age of 10 years. Young children usually fracture the distal radius when they fall upon the outstretched hand. You will have scope to reconsider if you have requested ordinary wrist X-rays and find the patient to be developed beyond the usual level for his or her age.

X-rays of the hand

A lateral X-ray of the fingers will be very overlapped at the level of the MCPJs, and it is usual to request hand views (PA and oblique) for that area. However, beyond the MCPJs the fingers can be separated and lateral views can be taken of each digit. These are much more helpful for assessing the possibility of such common injuries as a volar plate avulsion fracture at the PIPJ. The thumb can also be isolated for imaging from its carpal articulation distally, and therefore requests should be for the individual digit in all of these cases.

Hand X-rays are most commonly requested for suspected metacarpal injuries. Metacarpal injuries around the MCPJ are well visualised on hand X-rays but base of metacarpal injuries may incorporate an unstable dislocation of the bone's base which can only be assessed on a lateral view. A lateral view may also be requested specifically to measure the forward angulation of a displaced fracture of the shaft of the bone.

INJURIES

The complexity of the hand, its ceaseless and varied activity and the fact that it is raised to defend the body from any

Box 8.2 Examination of tendons

Examination of every individual muscle *in isolation* is a necessary skill. This is difficult in the hand. Certain principles of muscle action and examination can help you.

1. If the muscle is alone, at the end of the digit, then it can be assessed with confidence because no other muscle enters the assessment (extensor pollicis longus, flexor pollicis longus, flexor digitorum profundus).
2. If the muscle does something which no other muscle does, test that aspect of its function (flexor carpi ulnaris flexes the wrist and moves it into ulnar deviation).
3. If you test a muscle that goes to a proximal joint, make the muscles that pass on to the end inert, so that the muscle that you are testing has to work. The distal muscle has to operate at its insertion point as well as the proximal joint. When you test a proximal flexor leave the distal joint in extension; when you test a proximal extensor leave the distal joint in flexion (flexor digitorum superficialis, flexor pollicis brevis, flexor digiti minimi, extensor pollicis brevis, abductor pollicis longus).
4. If you have symptoms which could arise from more than one muscle, but one of the suspects crosses two joints while the others do not, test the patient at both joints. If symptoms arise from both tests the twin joint muscle is likely to be the cause (biceps, gastrocnemius).
5. If a muscle shares a distal joint with other muscles, test it at a more proximal joint where it is alone (extensor digitorum communis).
6. Muscles are interdependent and movement of one may trigger movement of another. The flexor carpi ulnaris inserts into the pisiform, as does the abductor digit minimi. When the little finger is abducted the wrist flexor contracts to stabilise the pisiform. Flexor carpi ulnaris also contracts when the extensors of the fingers are used.
7. The tenodesis effect is the way in which joints lie in certain positions when the hand is held in a particular way because of the natural tension in tendons which cross several joints. Tendons which cross more than one joint are not long enough to let each joint move to its full range simultaneously. This posture will change if the tendon is divided because the shortness of the tendon no longer limits the joint. When the hand is supine the fingers will normally curl into flexion and the wrist will extend slightly, with the amount of flexion increasing in each finger from index to little. If the flexor tendons are cut, the supine wrist will extend, and so will the fingers. The tendons are divided so nothing prevents the fingers from straightening.
8. Passive pressure on flexor tendons in the palmar wrist can reproduce flexion in the fingers involuntarily. This can be helpful with children who cannot cooperate with testing.
9. If a single muscle belly gives rise to several tendons they will work together when the muscle contracts. You will be able to prevent one of these tendons from operating by suppressing the activity of the others. This can allow you to isolate other muscles which operate in the same area (flexor digitorum profundus, extensor digitorum communis).

expected impact mean that the upper limb is the part of the body which is most often injured. A few common presentations are described here.

Hand splinting

If the hand is to be splinted or restrained by a heavy bandage, be aware that prolonged immobilisation can cause joint contractures and is not beneficial for the intrinsic muscles. The collateral ligaments of the MCPJs contract if the joints are kept in full extension. The volar plates of the IPJs contract if those joints are held in flexion.

The so-called **safe** position (also known as the **Edinburgh** position) of the hand requires that immobilisation is carried out with the MCPJ flexed to about 80 degrees and a very slight flexion of the IPJs, for comfort, and the thumb in abduction. Different texts give slightly different details of this position, but the principle is clear.

Fractures

The fall on the outstretched hand

Falling onto the outstretched hand results in a forceful impact through a straight arm with the wrist extended and the forearm pronated. Injuries to ligament (and other soft tissues), bone and joint can occur anywhere in the wrist and arm.

In the forearm, fractures occur in either the radius or ulna, or, commonly, in both. Any severe angulation or displacement of one bone will cause a dislocation between these two bones at the proximal or distal articulation. The **Monteggia** pattern of injury is of a fracture of the ulna with dislocation of the radius at the proximal joint. A young child may have a dislocated head of radius with no sign of a definite fracture of the ulna. In that case a 'bow fracture' of the ulna is likely. The injury termed **Galeazzi** is the reverse

Box 8.3 **Examination of deep structures of the hand**

- Bone – X-ray to exclude fracture.
- Joint – X-ray for dislocation. Refer for exploration if joint penetration is suspected.
- Nerve – resisted muscle tests for motor, and light touch for sensory change distal to wound. Light touch is enough, but compare it to the unaffected side. A small deficit is significant.
- Blood vessels – stop bleeding by pressure and elevation, assess distal perfusion, colour, warmth, pulses and capillary refill time compared to unaffected side. The Allen test. If wound stopped bleeding before the patient arrived, it will stop again. Do not tie anything off, cut anything out or explore with anything sharp.
- Muscles and tendons are the most difficult of the deep structures to assess. Tendons may be tested by eye, if the injury is open, through the full range of movement, and by resisted tests done carefully in case of partial tear. Do not assess movement if glass is thought to be in the wound or if you already have high suspicion of a partial tear.

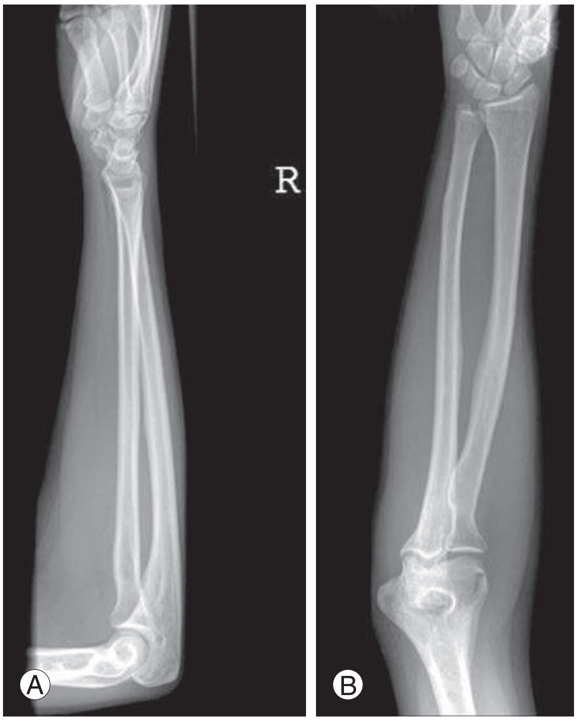


Fig 8.31 X-rays of the forearm. (A) Lateral and (B) anteroposterior.

pattern, with radial fracture and dislocation of the distal ulna. The Galeazzi fracture is much less common than the Monteggia.

The older person who falls on the outstretched hand is likely to suffer a **Colles fracture** (see Fig. 8.37A). This causes a characteristic 'dinner fork' deformity of the wrist. There is a dorsal and radial displacement of the distal radius and impaction. The ulnar styloid may also break. There is a specific risk of compression of the carpal tunnel with symptoms of median nerve paraesthesia (to the thumb, index and middle fingers, and the radial side of the ring finger). The neurovascular condition of the hand should be assessed carefully. Median nerve involvement makes reduction of the displacement a matter of urgency. An open Colles fracture may show no more than a small puncture wound at the ulnar styloid. This requires immediate orthopaedic referral. A closed Colles fracture which has no neurology complications is assessed for whether it needs reduction according to the degree of angulation of the radius and the integrity of the distal radioulnar joint. The patient is usually elderly so hand dominance, social factors and medical history are relevant to the decision-making process. The patient is given a local anaesthetic into the wrist and the impacted bone is pulled into a straight position and immobilised in a cast. If the procedure is unsuccessful surgery may be undertaken.

A patient who is injured by the less common mechanism of forced flexion of the wrist may have a displaced fracture of the distal radius which is tilted in the opposite direction to the Colles fracture, towards the palm. The **Smith's fracture** is too unstable to be treated by closed methods. The patient should be referred to orthopaedics for admission for surgery.

Children can also have severely angulated forearm fractures, which require correction, but greenstick and torus (or buckle) fractures with minimal deformity are more common. Greenstick is an injury caused by an angulation force, with a break in the periosteum on one side of the bone, and a fracture which does not pass fully through to the other side. Torus is an axial crush of the bone which shows no gap in the cortex, just an impaction bulge with angulation on one side. There is often very little to see in the way of bruising or swelling with these injuries but there will be pain, local tenderness, guarding of the limb and a reluctance or inability to use it. As with all forearm fractures, the elbow must be carefully assessed to exclude a double injury.

It is common for younger adults who fall on the outstretched hand to suffer a fracture of the scaphoid, especially across the narrow waist of the bone. It is forced against the lip of the radius by the hyperextension of the wrist. The hazards which non-union of a scaphoid fracture can cause have been discussed above. Tenderness in the anatomical snuffbox, especially if reinforced by tenderness on the

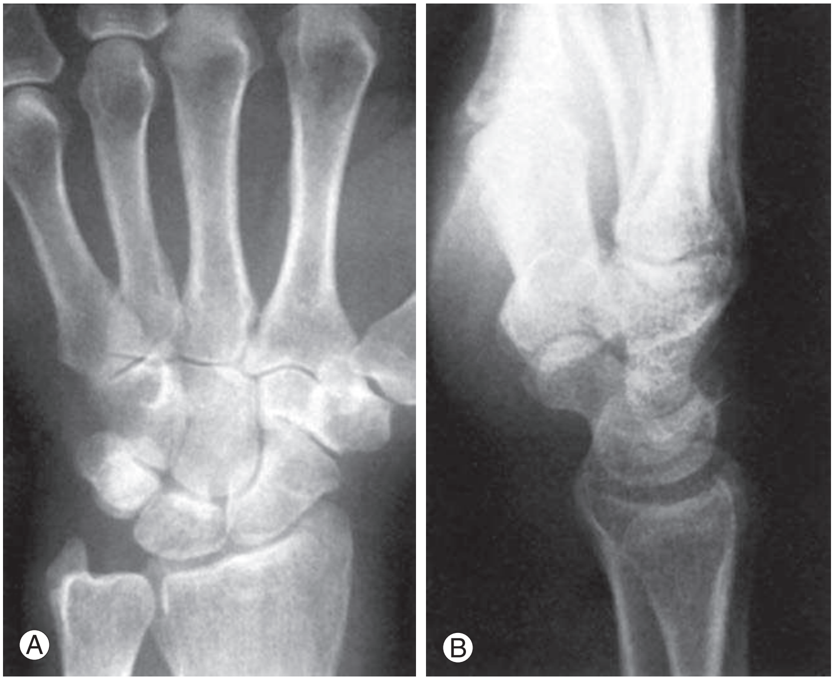


Fig 8.32 Wrist X-rays. (A) Anteroposterior and (B) lateral.

palmar and dorsal aspects of the bone, is the chief clinical sign of scaphoid fracture. Swelling over the anatomical snuffbox, inability to oppose the thumb to the little finger because of radial wrist pain and pain on axial compression of the thumb against the scaphoid (telescoping of the thumb) are other indicators. The wrist should be X-rayed and either three or four (according to local policy) **scaphoid views** taken (see Fig. 8.33). Scaphoid fracture may not be detectable on the first X-ray film, even if it has occurred, and the fact that the clinical signs are present means that the patient must be assumed to have a fracture. Each clinical area has its own variation on the policy of immobilising the injury in a scaphoid splint or cast (with the thumb held in a straight line with the axis of the forearm) and reviewing the patient between 1 and 3 weeks later. A fresh series of X-ray films may then reveal the signs of a healing fracture, and the patient can be reassessed clinically. The increasing availability and sensitivity of MRI is gradually redefining practice around this problematic injury. Treat any case where doubt remains on clinical grounds as a fracture.

Hand fractures

The base of the metacarpal of the thumb can be fractured, usually by forced abduction or the impact on the thumb of punching. The thumb looks shortened and is swollen at its base. The **Bennet's fracture** divides the base of the bone, leaving a small medial fragment sitting on the trapezius while the APL pulls the rest of the bone radially. This injury needs orthopaedic review and may need surgery.

Another punch injury, called the **boxer's fracture**, is an angulated fracture of the fifth metacarpal. The injury is usually close to the head of the bone. The definition of the knuckle is lost (it is tilted into the palm) and extension of the MCPJ is much reduced. There is usually gross swelling in the ulnar half of the dorsal hand and bruising is often seen in the midpalm. Look closely at any wound on the injured knuckle: human tooth wounds, so-called 'fight-bites', are a common feature of this injury. Policies vary for management of this fracture, and sometimes the angulation needs correction; immobilisation varies from simple buddy strapping to a volar plaster slab.

Fractures to metacarpals and to the proximal phalanges of fingers may also be deformed by axial rotation of the distal part. This may be hard to see when the hand lies prone with the fingers straight, but attempts by the patient to close the fist will show 'scissoring', where the fingers cross over each other so that normal coordination is impossible. Rotational deformity must be corrected at once so that coordination is preserved (Fig. 8.39).

Beware of a patient who falls on the hand and presents with a small, ragged wound on the flexor side of the palmar

Fig 8.33 X-rays of the scaphoid with fracture of waist of scaphoid.

MCPJ, especially of the little finger. The same injury can occur at other joints. The joint may have dislocated, torn the skin and then reduced again. The injury can look small, but there may be fracture, significant soft tissue injury and contamination of the joint.

Finger fractures

See metacarpal fractures for rotational deformity.

Hyperextension of a finger causes explosive tension at the tightest part of the palmar surface, at the PIPJ: the collateral ligaments pull the volar plate and it, in turn, avulses a fragment from the base of the middle phalanx.

Avulsion of the dorsal base of a distal phalanx is often caused by a violent pull on the extensor tendon (an avulsion **mallet** injury – see Fig. 8.40a). This injury is usually treated in the same type of splint as the related mallet tendon rupture.

Crush injuries are common to the distal phalanges, often caused by closing the finger in a car door. There may be joint or tendon injuries. There is often a subungual haematoma (a bleed under the nail) which can be relieved by making a hole in the nail, a process called 'trephining'. See 'soft tissue injuries' for nail bed lacerations.

Finger fractures are often treated with buddy-strapping, rest and elevation. Assess them on their merits. The degree of instability, joint involvement, soft tissue damage and neurovascular effects are all important indices of severity.

Soft tissue injuries

Skier's (gamekeeper's) thumb

A fall while holding a ski stick or one where the thumb is caught in the matting of an artificial ski slope can force the

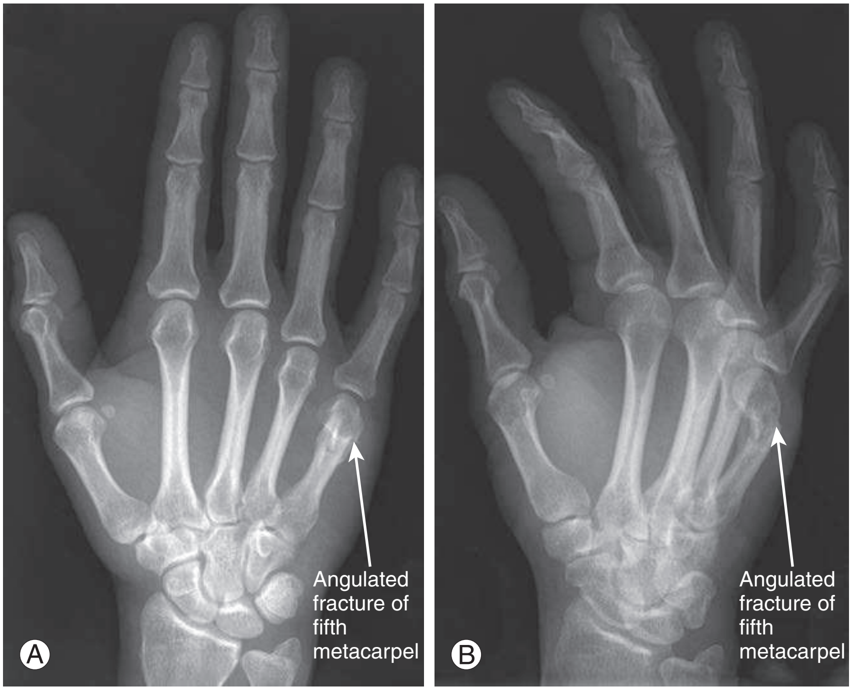


Fig 8.34 X-rays of the hand with a boxer's fracture.

thumb into violent abduction and rupture the ulnar collateral ligament of the MCPJ, an injury known as 'skier's thumb'. It is also called 'gamekeeper's thumb' in some rural parts because the recoil of a shotgun can cause the same injury. A grade 3 tear can render the joint unstable and it should be immobilised in a cast or splint and referred to an orthopaedic trauma clinic. The ligament on the radial side can occasionally suffer a similar injury (Fig. 8.38).

Tissue loss to fingertips and nail bed lacerations are dealt with in Chapter 16.

Distal phalanx injuries in children

The extensor tendon joins the dorsum of the distal phalanx of a child's finger proximal to the physis, while the flexor attaches on the palmar side distal to it. If the fingertip is fractured at the growth plate the flexor can tilt the distal part and displace it, usually uprooting the nail and lacerating the nail bed. Seek paediatric opinion on fingertip injuries in children.

Tendon tears

Complete tears of the extensor slips of the middle and distal phalanges of the fingers both produce characteristic deformities (Fig. 8.40). The tendon is often damaged by an axial injury or a crush (or cut) to the insertion of the tendon. The problem with the middle phalanx injury is that the radial and ulnar bands of the extensor mechanism may disguise the injury at first because they continue to extend the joint even without the support of EDC. These bands then, in later days, slip towards the palm and cause a fixed flexion deformity at the PIPJ, with forced hyperextension at the DIPJ (a boutonnière deformity). At this stage it may be too late to treat the finger. Careful technique is required in exploration of wounds and resisted testing of the muscle. Further advice should be sought for any patient where such an injury is possible.

Complete rupture of the distal extensor tendon produces an immediate flexion droop at the joint, a **mallet deformity**, which can be corrected passively. Request an X-ray of the finger to exclude an avulsion injury. A mallet splint is applied to the finger and the patient is referred for orthopaedic management. Once a mallet splint is applied it is important that the patient knows that the fingertip should not be allowed to flex. Healing relies upon a maintained contact of the torn ends of the tendon.

Rugby shirt finger is the equivalent on the flexor side of a mallet injury to the ring finger. The name of the injury

Fig 8.35 X-rays of the thumb. (A) Lateral and (B) anteroposterior.

Fig 8.36 A lateral X-ray of the fingers.

suggests a mechanism of injury where a child, usually an adolescent, grabs the collar of an opponent at rugby who pulls free and forcibly extends the patient's fingertips. The force of the pull catches the ring finger and tears the flexor digitorum profundus. This injury is less obvious than a mallet finger because the end of the finger remains in extension. The flexor tendon retracts quickly along its sheath when it is torn and the injury will be beyond repair in 10 days or so. It is easy to miss the fact that a patient has no movement at the end of a painful finger on a first presentation. Make it a rule that, however painful a finger is, you will elicit at least a flicker of flexion at the tip before you discharge a patient (Box 8.4).

Overuse

Tenosynovitis is common at the wrist, on the thumb side, in the combined tendon passage of the abductor pollicis longus and the extensor pollicis brevis (**de Quervain's tenosynovitis**). There will be pain on movement, crepitations may be present and holding the thumb adducted in the palm with ulnar deviation of the wrist (Finkelstein's test) will cause pain. Rest usually settles the problem. A thumb extension splint offers relief from painful movements.

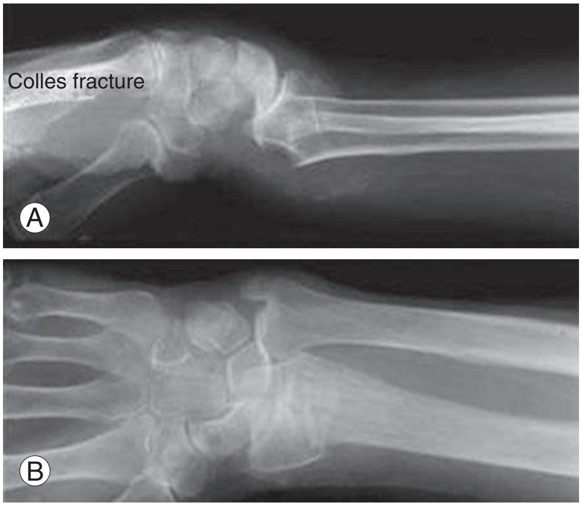


Fig 8.37 A Colles fracture. (A) Lateral and (B) anteroposterior.

Fig 8.38 The ulnar collateral ligament of the metacarpophalangeal joint of the thumb. This ligament can be ruptured by violent radial abduction of the thumb: so-called skier's thumb.

Fig 8.39 Rotational deformity with scissoring.

Infections

Paronychia is the commonest hand infection, usually caused by staphylococci. It sets in at the nailfold and causes a pus-filled painful swelling, and sometimes a spreading cellulitis. It is usually treated by incision and drainage; it sometimes requires an antibiotic if there is an ascending lymphangitis (a 'tracking' infection), cellulitis spreading above the DIPJ or if the patient is ill.

Pulp infection affects the volar side of the distal phalanx, with swelling, tenderness and pain. There is a collection of pus which requires release by incision and drainage.

Purulent flexor tenosynovitis is a hand infection that requires aggressive treatment. The sheath of the flexor tendon of the finger becomes painful, swollen and tender. The finger tends to curl, and any attempt to extend it passively is painful. It can spread through the whole hand very quickly, and should be treated with intravenous antibiotics. The clinical signs of flexor sheath infection are collectively known as **Kanavel's signs**, flexion of the finger, inability to tolerate passive extension, swelling, especially on the line of the flexor sheath, and tenderness along the sheath.

Amputations are discussed in Chapter 16.

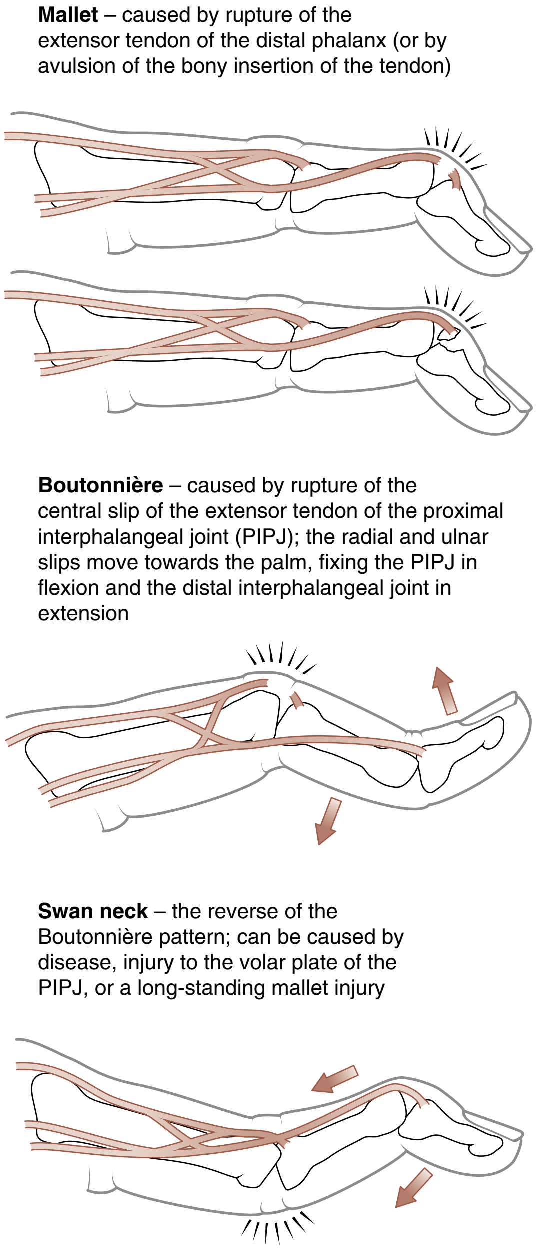


Fig 8.40 Common deformities of the finger.

Dislocations of fingers can occur at any joint, and are occasionally seen in all joints of the same digit. Normally the displacement of the distal part is dorsal and proximal. Assess perfusion and sensation, ensure that the skin is intact, X-ray to confirm dislocation and exclude fracture. If the injury is

Box 8.4 Rugby shirt finger

- Less obvious than mallet finger because the finger's posture can look relatively normal.
- Occurs in adolescence to the ring finger.
- Forced extension of the distal phalanx (as in grabbing someone's collar at rugby) tears the FDP tendon.
- Requires surgery in less than 10 days.

open refer the patient to orthopaedics for theatre toilet of the joint. Ring block the finger and reduce the displacement. Gentle, firm traction towards the tip of the finger may be enough. Sometimes, if the volar plate is trapped behind the bone, the dislocated part has to be hyperextended and lifted over the head of the proximal bone with traction. Injuries, especially at the MCPJ, can incorporate trapped soft tissues which will prevent closed reduction. In that case refer the patient to orthopaedics for open reduction.

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Chapter | 9 |

The pelvis and hip

CONTENTS

INTRODUCTION

The notion of the three ages of man, childhood, maturity and old age, offers itself easily to a variety of images and reflections well beyond the medical world and it has appeared in art and philosophy since ancient times. One of the themes of such images is that old age echoes childhood in ways that are poignant because the child is moving towards independence while the elderly person is declining from it.

These universal patterns show themselves in minor injury units (MIUs) as much as anywhere else: a distinctive feature of the hip, compared to the other joints of the limbs, is the extent to which presentations correspond to the patient's stage of development. The hip is stable and large and it is less subject to the effects of small accidents than the knee, ankle or foot. Its problems tend to be structural: they gather around its weakest point, the neck of the femur, slender and angled, its head bowed to receive the weight of the trunk. Healthy adults have no 'minor' trouble with the bones and joint structures of hip and pelvis: they do occasionally tear a muscle but, as to bones and joints, they will either suffer a major injury or nothing at all: childhood and old age are the times when vulnerability is amplified by immaturity or decline.

If you work in an MIU you will notice occasionally that emergency nurse practitioners (ENPs) who are perfectly comfortable with every other aspect of their work will draw a sharp breath when they realise that they will have to examine a patient's hip. This is not because the hip is more difficult than another joint to assess: it is because hip presentations are so infrequent among minor injuries, unless you see a large number of children, that the ENP has not developed the confidence which comes from exposure.

The 'hip' is a single joint but the word is often used to indicate any of a combination of structures in that area: the sacrum, the bones of the pelvis and the local muscles and ligaments. A patient may mention other words such as 'the groin' when he or she has a problem around the hip.

The language is vague partly because it can be difficult to localise symptoms around the hip: pain may radiate to a distance from its source, and referral of pain is also very common. Symptoms around the hip may arise from organs, blood vessels, musculoskeletal and neurological structures sited in the abdomen and the back as well as in the area of the joint itself.

The language is also vague because the hip, like the shoulder, lies deep. The other limb joints are surrounded by muscle but are themselves superficial. It is therefore more difficult with hip and shoulder to distinguish muscle from joint problems and to see if the joint is red or swollen. Added to this is the fact that a structure is more likely to refer pain the nearer it lies to the trunk. Symptoms that arise around the hip are often felt as pain further down the limb, commonly at the knee.

The three ages of the hip:

- From birth until the completion of growth there is a tendency to have problems at the neck of the femur which may compromise circulation and lead to avascular necrosis of its head, the epiphysis of the growing bone. Children are also prone to infections, osteomyelitis (infection of the bone itself) and septic arthritis (infection of the joint). There can also be a tendency to suffer avulsion fractures around the pelvis and femur when attached muscles are overloaded. The fully grown adult is more likely to tear the muscle itself.

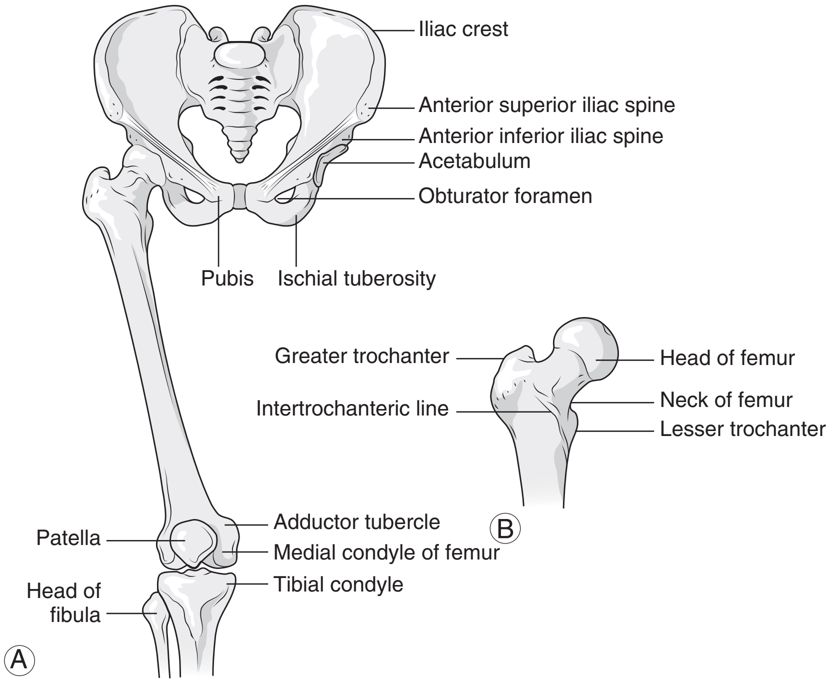

Fig 9.1 A, The pelvic girdle and femur – anterior view. B, The proximal femur – anterior view.

- The pattern of injury in adults who are not yet elderly and who have no history of childhood hip problems is dictated by two factors: the hip joint is strong and very stable, and it is firmly supported by strong ligaments and a thick covering of muscle. The ligaments themselves are unlikely to be injured by a 'minor' mechanism because they are strong and because the muscles which cover the joint are relatively limited in length and are likely to be the first tissue to tear if the hip is overstretched. The other structure which causes problems for adults is the bursa, of which there are three main culprits around the joint: these are the bursae of the **greater trochanter of the femur**, of the **ischial tuberosity** and of the **iliopsoas hip flexors** in the groin. Therefore the active adult is most likely to present with muscle tears (the so-called groin strain and others) and, occasionally, bursitis. Injuries around the hip joint are the least common limb presentation in adults.
- In old age the bones become more fragile and the tendency to fall, long since outgrown, returns: even a minor fall can fracture the neck or other parts of the proximal femur, and the pelvis itself becomes vulnerable to fracture. As in childhood, interruption of the blood supply through the neck of the femur to the hip joint can cause avascular necrosis of the head of the femur, and a prosthetic replacement of the joint may be needed. Dislocation is an uncommon problem at the hip (the congenital tendency to dislocate the hip is usually detected and managed at birth) but prosthetic joints dislocate more readily.

ANATOMY

The **pelvic girdle** relates to the leg as the shoulder girdle does to the arm (Fig. 9.1). The pelvis is also a bilateral and symmetrical structure which connects limb to trunk. It has articular sockets for the heads of the femur. The hip joints are synovial capsules with ligament and muscle reinforcement.

There are, however, significant differences between the pelvic and shoulder girdles. The bones of the pelvic girdle are much more rigid in their unity and correspondingly less mobile. They meet in the midline of the body at the front and form a complete bony ring by articulating at the back, at the slightly moveable **sacroiliac joints**, with the sacrum. Through this articulation, the pelvis is in direct contact with the vertebral column. The upper part of the

pelvis forms a kind of abdominal basin, holding organs of the gastrointestinal, reproductive and urological systems. The lower part forms a channel, the pelvic canal, through which these organs have outlets for their external functions.

The **hip joint** itself reflects the major difference in the functions of arm and leg. Both limbs are concerned with movement. The arm places the hand in space. The leg carries the weight of the whole body through space and also, in coordination with the upper body, stabilises the body both at rest (especially when standing) and in motion. The hip joint is, consequently, larger and much more stable in its deep ball and socket structure. It permits a smaller range of movement, with a greater emphasis on basic flexion and extension, than the shoulder joint. The bones and muscles of the leg are larger than those of the arm, adapted for weight bearing and power rather than fine movement. The hips are closer together than the shoulders. The legs are central pillars that meet in the midline of the body while the shoulders are widely spaced so that the arms are lateral appendages.

The pelvic girdle is an assembly of three pairs of closely united bones: the **ilium**, the **ischium** and the **pubis**, combined with the **sacrum**. The ilium, ischium and pubis are collectively named the **innominate** (nameless) **bone**. The innominate, seen from the front, looks slightly like a human ear, with the iliac crest as the upper ridge, the helix, and the arches of pubis and ischium as the lobe. The place where the three bones of the innominate meet and fuse is called the **acetabulum** (Fig. 9.2). The acetabulum is the socket which articulates with the **head of the femur** to form the hip joint.

Ilium

The ilium is the upper pelvic bone, an expanded, cupped dish. It meets the sacrum on its medial border with the pubis below to the front and the ischium below to the back. Its main inner surface, called the **iliac fossa**, forms the pelvic basin, which supports the abdomen. Behind the fossa, the ilium articulates on its inner, medial surface with the sacrum and offers attachment for the sacroiliac ligaments. It has a semi-circular **iliac crest** as its upper border, which passes from front to back and can be felt, and usually seen, just below waist level. The crest ends in two prominences, one at the front and the other at the back: the **anterior superior iliac spine** and the **posterior superior iliac spine**, respectively. Below each of these spines, both of which are palpable, lie lower, deeper spines separated from the upper ones by a notch. These are the **anterior inferior iliac spine** and the **posterior inferior iliac spine**. The acetabulum, of which the ilium forms the upper section, is found on the outer face of the ilium, at the lowest part of the bone.

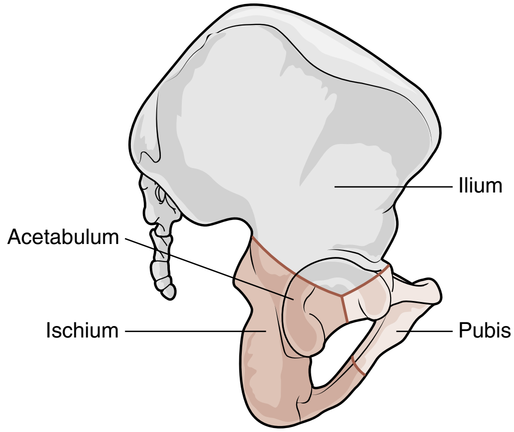

Fig 9.2 Lateral pelvis.

The pubis

The two pubic bones meet in the midline at the front, at the angle where the abdomen ends and the genitals emerge, at a non-synovial, cartilaginous joint called the **symphysis pubis**. From here, each pubic bone divides into two fingers of bone, both of which travel backwards and outwards. The upper one, the **superior ramus** (meaning upper branch), fuses with the ilium and ischium at the acetabulum. The lower branch, the **inferior ramus**, fuses with the ischium at the **ischial ramus**.

The ischium

The two ischial bones form the lower, rear part of the pelvis. They do not meet in the midline like the pubic bones. The space between them is part of the canal of the pelvis. The circle of the pelvic girdle is only closed at a higher point at the rear, at the sacroiliac joints. The lowest and most posterior part of the ischium, the **ischial tuberosity** (the bone in the buttock which contacts the chair when sitting), is angled in a similar way to the pubis, travelling upwards to its fusion at the acetabulum and inwards and forward as the ischial ramus, to the inferior pubic ramus. An irregular oval area called the **obturator foramen** (a foramen is a passage, usually a channel through a bony structure) is enclosed by the ischial–pubic ramus below and the meeting of the ischium and pubis at the acetabulum above.

The femur

The femur is the thigh bone. It is the longest bone in the body. At its proximal end, it forms the ball of the ball and socket hip joint. In comparison with the humerus, it has a more completely spherical **head** and a much longer **neck**. The head is covered in hyaline cartilage and has a small

hole on its medial surface through which it is connected to a ligament inside the acetabulum. The neck is angled upwards towards the pelvis, at approximately 125 degrees from the shaft of the femur. The shaft expands at the point of union with the neck, with two processes on its lateral and medial sides. The large, lateral one is the **greater trochanter** and the medial one, under the angle of the neck, is the **lesser trochanter** (see Fig. 9.1B).

Ligaments

There are three stabilising ligaments, which are of special importance at the hip because they limit extension and help to maintain the upright position with a minimum of muscle effort. These are the **iliofemoral**, the **pubofemoral** and the **ischiofemoral ligaments**. Of these, the iliofemoral or Y ligament is the strongest and most significant in the limiting of extension. It lies in front of the joint and runs from the anterior inferior iliac spine to the intertrochanteric line of the femur.

EXAMINATION

The hip joint is best palpated at the back, in the lateral hollow of each buttock.

In the event where you are examining a patient with knee pain, especially a child, and you are suspicious that the pain is referred from the hip, the examination must be carefully organised. In clinical areas the hip is usually examined with the patient lying supine on a trolley. In this position it is difficult to elicit movements at one joint without moving the other, and this can make it difficult to decide where the symptoms originate. You can modify your examination by changing the patient's position. Some movements can be tested with the patient prone on the trolley, and some can be tested with the patient sitting on a chair or the side of the trolley.

Look

Displaced fractures at the neck of the femur move upwards, causing the leg to shorten. The action of muscle around the fracture also causes the leg to rotate outwards at the hip. The tendency to shortening and lateral rotation is also found in an adolescent with slipped capital femoral epiphysis.

If the patient is able to walk, look for a limp or signs of discomfort. Ask the patient to undress to underwear and put on a hospital gown. The hip is examined with the patient lying on a trolley in prone and supine positions, but take a look at the spine and general posture while he or she is standing: examine the lower back and the abdomen. You will perform certain parts of your assessment with the patient standing, and others with the patient prone or supine on a trolley.

Pelvic structures are covered by muscle, ligament and fat and there are differences in how they look depending on gender, weight, physical type and stage of development. Some landmarks are:

- At the front, the abdomen meets the thigh at a curving furrow, the groin fold or inguinal canal, whose upper, outer limit is a dimple over the anterior superior iliac spine. The inner point of the fold is its attachment to a spine of the pubic bone, slightly lateral to the symphysis.
- On the back, two small dimples at the lower ends of the erector muscle columns (the vertical pillars of muscle which protrude on either side of the central groove of the lumbar spine) mark the site of the posterior superior iliac spines. A small, depressed triangle pointing downwards from the base formed by a line between these dimples, into the cleft between the buttocks, is the site of the sacrum. At the bottom of the sacrum is the rounded coccyx which merges at its lower end with the cleft of the buttocks.
- On the side there is a furrow where the abdominal muscles and fat meet the hip. This furrow is not at the level of the iliac crest: it overhangs it slightly. The crest is often covered by these lateral abdominal structures but its anterior and posterior spines mark its limits, and it is easily palpated.
- The buttocks are prominent and rounded at their meeting in the midline: laterally there is a hollow between each buttock and the leg, and this is the site where the hip joint can be palpated.
- The greater trochanter of the femur is usually the widest point of the hip in the male. It is relatively superficial. Women are sometimes wider just below the trochanters depending upon the deposition of fat.

Feel

The three main bursae are at the widest point of the greater trochanter of the femur, on the prominence of the ischial tuberosity in the buttock and in the groin fold, within the flexor muscles. Box 9.6 describes the sites for pelvic avulsion fractures in adolescents.

The iliac crests can be palpated from the anterior to the posterior iliac spines. They are covered by the fold of the lateral abdominal muscles but are superficial.

The symphysis pubis is in the midline at the front at the same horizontal level as the greater trochanters of the femurs. Lateral to the symphysis on each side is the spine of the pubis, where the inguinal canal has its medial attachment. The lateral attachment of the inguinal canal is the

anterior superior iliac spine. The pulse of the femoral artery can be felt at about the mid-point of the inguinal canal.

To feel the greater trochanter of the femur, palpate downwards and outwards on the lateral pelvis from the iliac crest: it is felt at the angle where the finger turns inwards. Move medially from this point on the back, into the hollow of the buttock, and the hip joint can be felt.

At the back the sacroiliac joints can be approximated by palpating the depressed triangle of the sacrum, just above the cleft of the buttocks, to each side towards the ilium at the level of S2. These joints are covered by ilium and ligament and are not directly accessible.

The ischial tuberosities, the hindmost contour of the pelvis in each buttock, can be felt with the patient prone by pressing upwards in the midline of the buttock at the level of the greater trochanters. They are easier to feel if the patient lies on his or her side with hips flexed. The gluteus maximus muscle rises and uncovers the bone.

The hip joints can be compressed axially, towards the acetabulum, and this may elicit pain from a femoral or pelvic fracture. The pubis can be gently depressed when the patient is supine, and the sacrum when he or she is prone. A sacroiliac joint injury may also be symptomatic when the sacrum is compressed.

The bursa of the greater trochanter of the femur can be palpated on the lateral surface of the widest point of the femur. The bursa of the ischium is palpable on the bony prominence in the buttock. The iliopsoas bursa lies over the neck of the femur.

Move

Figures 9.3–9.8 show the active movements at the hip and resisted tests with the relevant muscle anatomy. Passive movements are not illustrated because the patient's position is the same for them as for the active movements.

You are called on to be versatile in your approach to the hip to a greater extent than to any other limb joint, depending on factors which include the patient's age, size, pain and agility, the nature of the injury and your own physical attributes. The leg is long and heavy and it is hard work for the patient to manoeuvre it from a horizontal position and it is challenging for you to handle. The main clinical issue with elderly patients who have fallen will be whether or not they have a fracture of hip or pelvis. Significant injuries to the muscles or ligaments are unlikely in these cases. The patient may have a great deal of pain and limited ability to move around the trolley: adapt your examination accordingly. In the case of children, the hip is easier to examine because the leg is smaller. Once again, as with the elderly, a great deal of your focus will often be on the joint rather than the muscles.

The hip is examined with the patient lying on a trolley, and your technique and observation must be accurate to ensure that there is no substitution of back movements for hip movements, and no use of the support of the trolley surface to disguise limitations in movements. The patient will not be aware that this is happening.

Passive movements involve handling of the whole leg: protect your own back and avoid hurting the patient at any of the leg joints. Show consideration if the patient is holding the leg in the air in one position or another: this is very tiring.

Your assessment of a patient with knee pain may include a hip examination if there is a possibility that the pain is referred from there. It can be difficult to move the hip without the knee and if both joints are moving you will not know where pain is coming from. The knee can be assessed before the hip, with the patient lying prone or sitting on the edge of the trolley. This will allow isolation of the joint. Once you have cleared the knee you can assess the hip with more confidence.

See Box 9.1 for assessment of the hip and Box 9.2 for hip statistics.

X-RAYS

An anteroposterior (AP) view is the only standard pelvis image. This image of the pelvis presents three bony rings (Fig. 9.9). The upper, central ring is the rim of the basin of the pelvis, passing from the sacrum at the back, around the ilia at the sides and the top margin of the pubic bones at the front. Below, the loop of the pubic and ischial bones on each side creates two symmetrical rings sitting side by side, the obturator foramina, which allow comparison of one side with the other. A double fracture within one loop is likely if any fracture has occurred. Look at the sacroiliac joints and the symphysis pubis: is there mal-alignment or widening? The sacroiliac joints should be equal in width and the top margins of the pubic bones should be level at the symphysis and the width of the symphysis should be 5 mm or less. If the perforations, or foramina, on the sacrum are distorted in shape this suggests one or more fractures. The other site where a fracture can occur is the acetabulum. Spaces are seen on a child's X-ray at the fusion point of the pelvic bones in the acetabulum and the junction of the inferior pubic ramus with the ischium. Adolescents are prone to avulsion of pelvic apophyses instead of muscle injuries. The common sites for such injuries are listed in Box 9.6.

An AP X-ray of the hip and pelvis allows you to consider the possibility of a pelvis fracture and compare the two hip joints. In addition a lateral view is done of the injured hip (Fig. 9.10).

The neck of femur can be assessed on both views and compared with the other side on the AP view. It should have a smooth cortex, uninterrupted trabeculae and no transverse sclerotic lines. The head of femur should be centred, not angulated on the neck, on the lateral view. A fracture can be

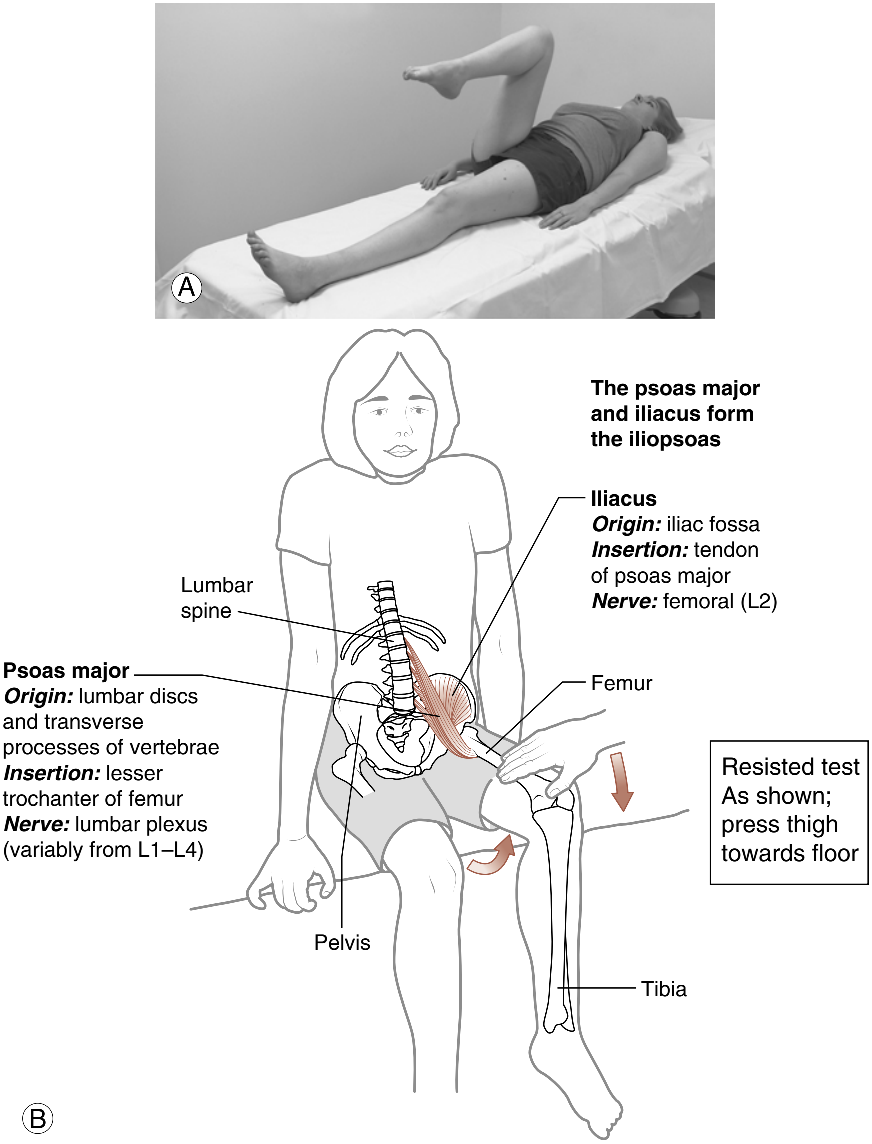

Fig 9.3 A, Active flexion of the hip. B, Resisted flexion of the hip, showing the flexor muscles.

very subtle and may even be unseen on X-ray. Therefore, any patient who is discharged with a negative X-ray may require further imaging if symptoms do not settle down.

INJURIES

Patients who present complaining of pain at the hip should be assessed with particular care, especially if they do not have a history of injury. The joint is large and stable and, from the point of view of the low-impact injuries which present to minor injury areas, relatively uneventful. There is, however, a tendency for ailments in the lower part of the abdomen to cause pain which is referred or radiates to the hip. The close relationship between the pelvis and the abdominal organs means that there are several local suspects as the source of any unexplained pain and referral from a lumbar spine problem must also be excluded. Other more broadly systemic diseases including cancers

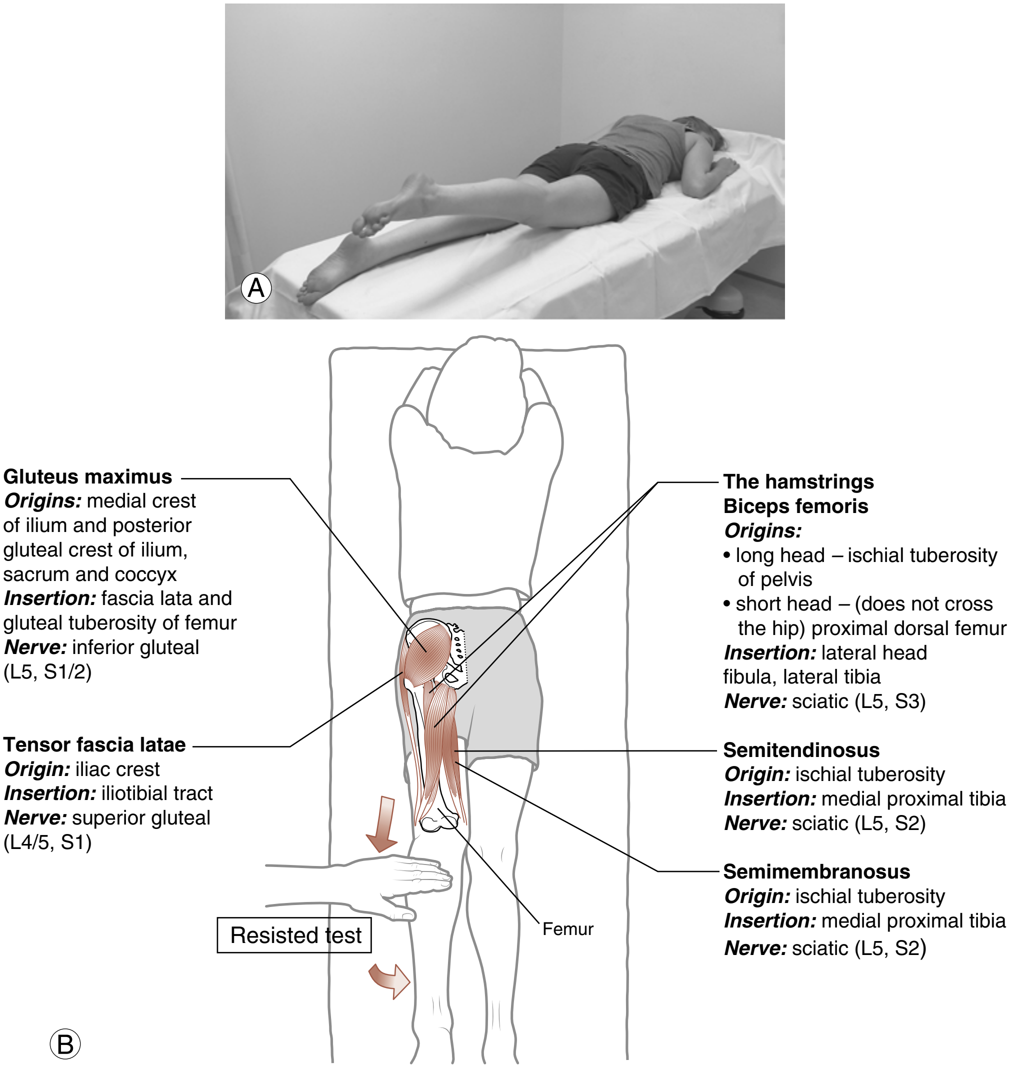

Fig 9.4 A, Active extension of the hip. B, Resisted extension of the hip showing extensor muscles.

can manifest with leg pain. As well as diseases of the main organs, symptoms can arise from problems such as hernias, especially inguinal and femoral, and various kinds of abscesses, fistulae and sinuses. Infection may cause tender enlargement of lymph nodes at the groin.

Childhood presentations (Boxes 9.3–9.5)

A child may present with a hip problem at any time from birth until the completion of growth, and may carry a legacy from a more serious problem into adulthood. Children with painful hips (or painful knees, which may be caused by referral from the hip), a limp or a reluctance or inability to weight-bear should be referred for medical assessment. The child will require assessment across a range of possible hazards, including arthritis, necrotic changes in the joint and other systemic diseases manifesting as hip pain. Osteomyelitis, an infection of bone, and septic arthritis, a joint infection, can also occur. You will have local policies for such eventualities. Always assess any child with hip pain for evidence of infection.

From birth until the completion of growth, children are prone to problems at the hip. Typical ages for these presentations are given but they are generalisations:

- **Transient synovitis**, or **irritable hip**, usually occurs between the ages of 2 and 7 years. The child has a

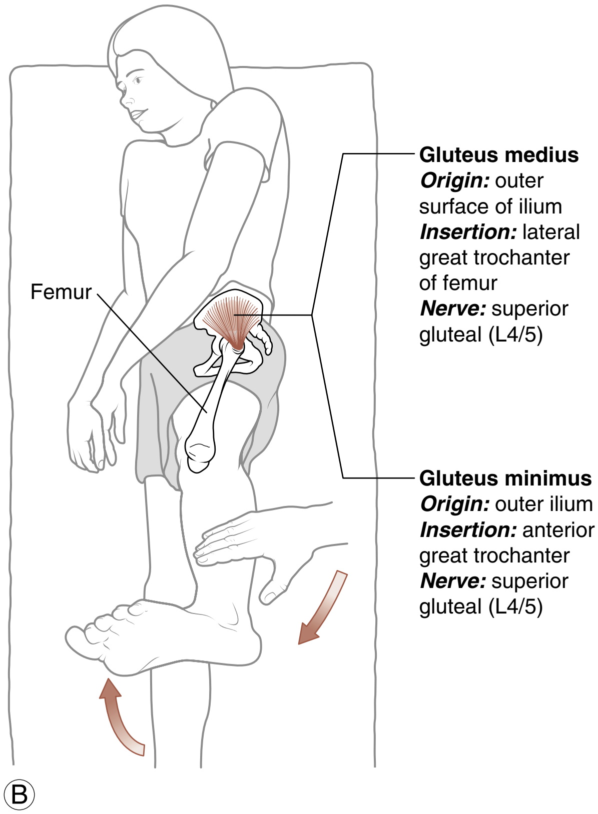

Fig 9.5 A, Active abduction of the hip. B, Resisted abduction of the hip showing the abductor muscles.

limp, not always painful. There may have been a preceding viral infection. There will be limitation of movement on examination, with or without pain. There should be no systemic illness. The diagnosis is accepted after ruling out other possibilities. Treatment is rest and the patient will be reviewed. Some patients go on to develop Perthes disease.

- **Perthes disease** presents between the ages of 2 and 8 years, with a history of a limp and a possible previous episode of irritable hip. The patient is systemically well. X-rays will show cysts and epiphyseal destruction in the hip joint caused by avascular necrosis. The problem will be managed by orthopaedics.
- Normally a growing bone has a blood supply on either side of the growth plate, so that injury through the physis does not interrupt perfusion to either side. In the hip joint the physis at the neck of the femur is inside the joint capsule and much of the blood supply to the head of the femur crosses

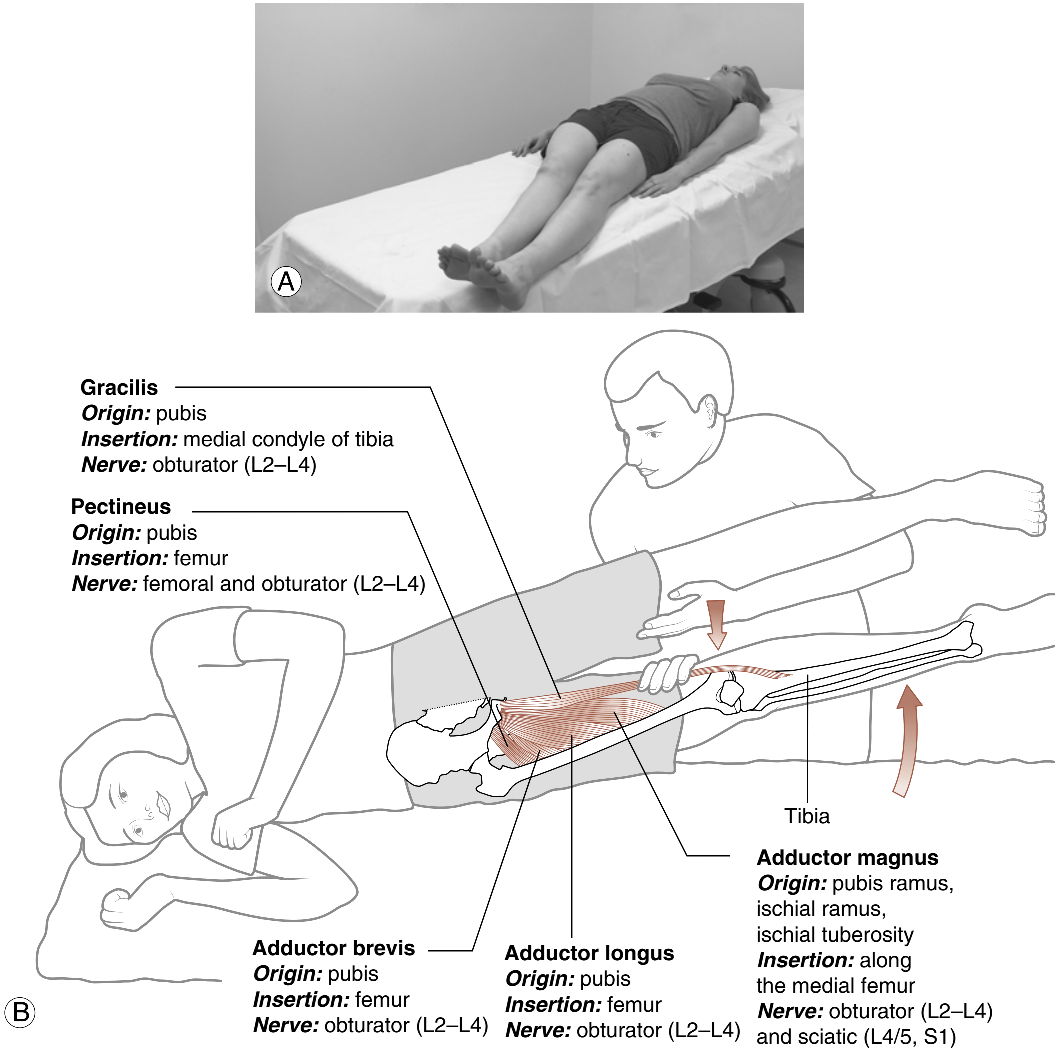

Fig 9.6 A, Active adduction of the hip. (This movement is sometimes shown with adducted limb crossing over the other.) B, Resisted adduction of the hip showing muscles of adduction.

from the shaft of the bone through the growth plate to the head: injury to the growth plate can impair perfusion and lead to avascular necrosis of the head of the femur. So-called (the femoral epiphysis is firmly bedded in the acetabulum and does not slip: the neck of the femur, the diaphysis, displaces upwards with lateral rotation) **slipped capital femoral epiphysis** (SCFE) is a condition which commonly affects boys at 10–16 years and girls at 9–15 years. SCFE is considered 'unstable' if the patient cannot walk. There is a 50% risk of necrosis. SCFE is associated with boys, obesity, hormonal effects on the physis and an adolescent growth spurt. There is a correlation with endocrine problems. Avoidance of later osteoarthritis depends on how well the relation of the head of the femur to the acetabulum is maintained. The patient presents with no history of injury or a slight injury with disproportionate disability. The patient may complain of knee pain which examination shows to be referred from the hip. Severe cases are non-weight bearing. If the patient is walking he or she tends to limp with lateral rotation of the thigh, which increases during hip flexion. There will be a loss of medial rotation. A quarter of patients have a bilateral problem.

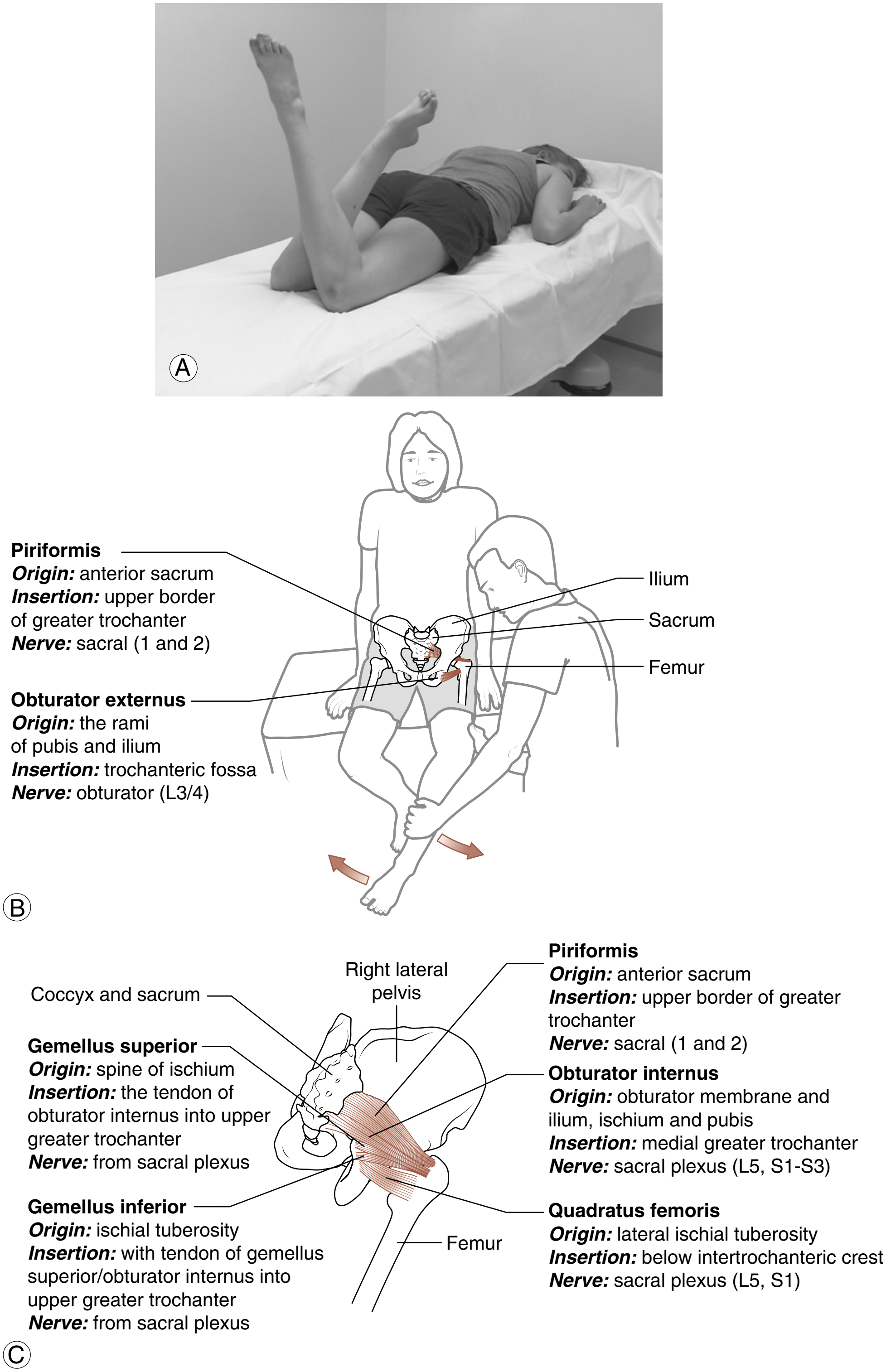

Fig 9.7 A, Active lateral rotation with hip at 0° flexion. B, Resisted lateral rotation showing muscles of lateral rotation. C, Muscles of lateral rotation of hip.

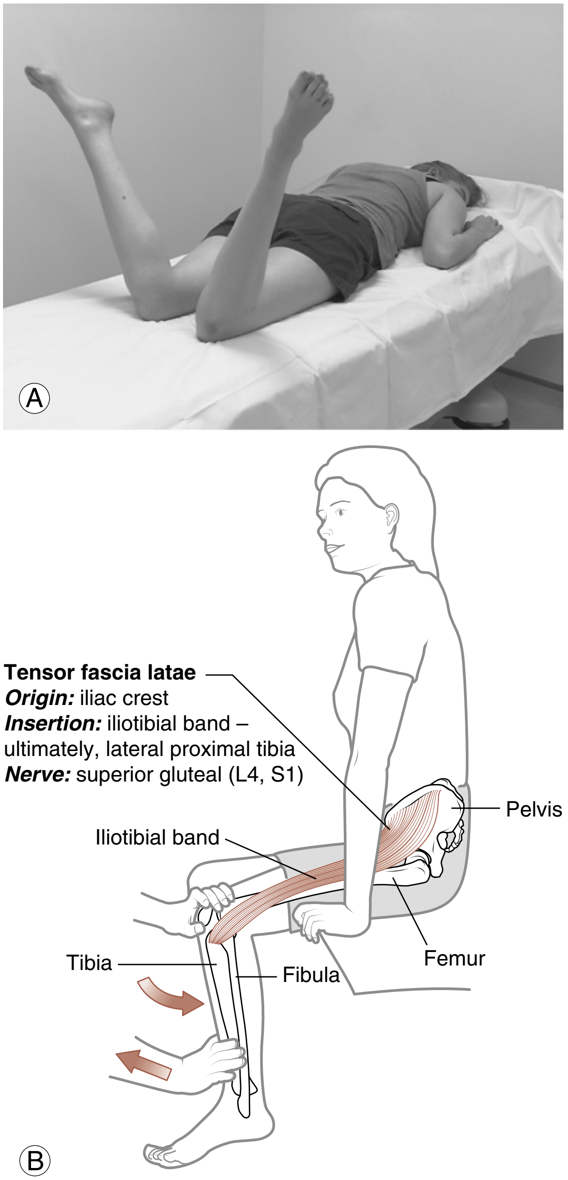

Fig 9.8 A, Active medial rotation of hip with hip at 0° flexion. B, Resisted medial rotation of hip showing muscles of medial rotation.

Sporty adolescents who have had a recent growth spurt, when the bones have lengthened and the muscles are, for a time, relatively short, may be prone to a specific pattern of injury around the pelvis. Violent exertion such as sprinting can cause an apparent muscle tear around the hip but the patient will be tender at the insertion point of the tendon into the pelvis or proximal femur rather than in the more likely belly of the muscle. The apophyseal attachment points are relatively soft until growth is complete and this, combined with the transient period of muscle tightness, can cause avulsion fractures during this phase of growth. X-rays around the pelvis involve considerable exposure to radiation for a young person: involve a senior or specialist from the time of presentation, before embarking on X-rays, so that management is optimum from the outset. Be suspicious if a young patient with an apparent muscle strain returns because he or she is not recovering. Some possible fracture sites are listed in Box 9.6.

Box 9.1 Hip assessment

You should be able to assess the hip through its full range of movement, and discriminate between musculoskeletal conditions and other problems.

- Palpate and ask the patient to show movement in the lumbar spine (see Figs 14.8–14.10).
- The movements of the hip are illustrated.
- PASSIVE movements are not shown: they are performed in the same positions as the ACTIVE range, except that the rotations will be performed using only one leg at a time.

Box 9.2 Hip statistics

- Capsular pattern: equal loss in flexion, abduction and internal rotation.
- Joint position: loose packed is 30° flexion, 30° abduction and a small degree of external rotation; close packed is full extension and internal rotation, with a small element of abduction.
- Flexion 0–120°; endfeel tissue approximation of thigh and abdominal muscles.
- Extension 0–30°; endfeel firm, stretch of capsule, ligaments and muscles.
- Abduction 0–45°; endfeel firm, stretch of capsule, ligament and muscle.
- Adduction 0–30°; endfeel firm, stretch of abductor muscles.
- Lateral rotation 0–45°; endfeel firm, stretch of capsule, ligaments and muscles.
- Medial rotation 0–45°; endfeel firm, stretch of capsule, ligaments and muscles.

Hip problems in adulthood

The fully grown adult is not prone to fractures, dislocations or ligament tears at the hip with the relatively low-severity injuries which present to MIUs.

Fig 9.9 AP view of the pelvis and hip.
Source: From Carver, E., Carver, B., 2012. Medical Imaging: Techniques, Reflection & Evaluation, second ed. Churchill Livingstone.

Fig 9.10 Lateral view of the hip.
Source: From Long, B., Frank, E., Ehrlich, R., 2010. Radiography Essentials for Limited Practice, third ed. Saunders.

A simple rule of musculoskeletal examination holds good for muscle tears at the hip joint: a passive replication of the painful movement will reduce or eliminate the patient's symptoms. Be careful if you find that this is not the case, and remember that organic disease can present with symptoms around the lower back and hip.

At the hip certain muscles are prone to overuse symptoms and to strains, especially in the sportsman. A few terms are in common use to describe these tears, including **groin strain**, **hamstring tear** and **quads tear**.

In the case of overuse, the pain follows the inflammation pattern of settling once activity is underway but returning after a rest; the pain gradually worsens if not treated and eventually becomes an established 'cycle of pain'. The standard treatment for acute episodes is rest and ice.

Muscle tears, or strains, in the hip and thigh are usually sustained during sport. Unbalanced, poorly controlled movements are particularly likely to make conflicting demands on muscles which cross more than one joint, such as the hamstrings, and a tear can result. Tears are managed with strict rest and ice in the initial phase to reduce bleeding and a treatment plan is calibrated to the severity of the tear.

These injuries can be challenging to manage. A torn hip flexor will cause the patient pain as soon as he or she attempts to lift the knee, which means that walking will be difficult or impossible. The normal response to a problem with weight bearing is to provide a walking aid, but even non-weight-bearing crutches require the patient to flex the hip. You may notice that the patient has discovered that passively lifting the thigh with his or her hands is less painful than active movement, for example when rising from bed or getting out of a car, and this can point you towards the diagnosis.

The muscles described below are the ones that are most prone, at the hip, to tears from overstretching. A compression force, a blow which crushes a muscle against bone, can happen at any site. In that case, the deeper muscles are the ones which are most likely to suffer damage.

The adductor longus

The adductor longus brings the leg to the body from the side.

If the muscle is inflamed, there is groin pain on movement, often with tenderness at the pubic origin of the muscle, symptoms elicited by resisted adduction and passive abduction.

If there is a strain, a sharp pain will be felt, followed by the symptoms of muscle injury, which may be pain and/or loss of function depending on how severe the tear is. There may, with complete rupture, be a palpable defect in the muscle.

The iliopsoas

The iliopsoas is the main flexor of the hip.

Inflammation can arise from overuse caused by any one of a variety of movements which involve raising the leg or sitting up, especially if weights are used. The pain is usually felt at the insertion of the combined tendon of the iliopsoas into the lesser trochanter of the femur. Note that there is a bursa under this tendon, and bursitis at this site would cause similar symptoms to tendon inflammation.

Box 9.3 Slipped capital femoral epiphysis

- Commonly affects boys at 10–16 years and girls at 9–15 years.
- The head of the femur does not slip, it is held in the acetabulum by the ligamentum teres. The neck of the femur moves up and out at the physis.
- SCFE is considered 'unstable' if the patient cannot walk. There is a 50% risk of necrosis.
- SCFE is associated with boys, obesity and the adolescent growth spurt.
- The problem appears to relate to weight-related stresses and hormonal effects on the physis.
- There is a correlation with endocrine problems.
- Avoidance of osteoarthritis depends on keeping the head of the femur related to acetabulum.

Box 9.4 SCFE clinical presentation

- No history of injury, or slight injury.
- Knee pain, referred from hip. Severe cases are non-weight bearing. Mobile patient limps with lateral rotation of the thigh, which increases during hip flexion, and cannot rotate medially.
- 25% of patients have a bilateral problem.

Strain might occur at the femoral insertion of the muscle, with pain at the time of injury, reproduced on examination by resisted hip flexion and passive stretching of the muscle with the hip in extension.

Piriformis syndrome

In a minority of people, the common peroneal branch of the sciatic nerve may be prone to compression by the piriformis muscle because the nerve passes through the muscle, instead of passing under it, into the back of the thigh. This may cause buttock pain, with referred numbness and weakness in the leg, which would seem to suggest a problem in the lumbar spine. The piriformis involvement can be demonstrated if stressing the muscle, which is a lateral rotator and abductor of the hip, in a resisted test or passive stretch, increases the symptoms.

Quadriceps tears

The muscles on the front of the thigh, the quadriceps, are extensors of the knee. Three of the quadriceps muscles do not cross the hip joint and are less prone to the sudden overload that 'two-joint' muscles can suffer. The fourth muscle, the rectus femoris, may suffer a partial or complete tear during a violent hip flexion or knee extension. Flexion of the knee to 45 degrees will stress the rectus femoris during hip flexion, and a resisted test can be done in this position. A defect may also be felt in the muscle if there is a severe tear. Passive flexion of the knee will be increasingly painful as the muscle is stretched.

Box 9.5 Hip pain in children

- Transient synovitis: ages 2–7, a limp, not always painful. There may have been a preceding viral infection.
- There will be limitation of movement on examination, with or without pain.
- There should be no systemic illness or other signs.
- Exclude more dangerous possibilities before accepting the diagnosis. X-rays, ultrasound and blood tests.
- Treat with rest and review.
- Some patients go on to develop Perthes disease.
- Perthes disease: ages 2–8 years, history of limp, possible previous transient synovitis.
- Systemically well.
- Will be limited in abduction with the hip flexed.
- X-ray will show cysts and epiphyseal destruction in the hip joint, caused by avascular necrosis.
- Orthopaedic management.

Box 9.6 Adolescent pelvic avulsion

In adolescents, muscle attachments to apophyses of the pelvis at:
- the ischial tuberosity (hamstrings) – the commonest of these injuries
- the anterior inferior iliac spine (rectus femoris)
- the anterior superior iliac spine (sartorius)
- the iliac crest (quadratus lumborum).

May be avulsed by vigorous exertion which would normally cause a muscle tear in an adult.

Hamstring tears

Three of the four hamstrings are 'two-joint' muscles (only the short head of the biceps has a femoral origin) which arise from the tuberosity of the ischium: their twin roles are extension of the hip and flexion of the knee. Injury can be caused by violent contraction of the muscle or overstretching, which is more likely in a 'two-joint' muscle. Passive stretching, in the direction of knee extension and hip flexion, may elicit pain in a partial tear. Resisted knee flexion will be painful in a partial tear, and weak if the tear is large.

There are various sites on both sides of the posterior thigh which can be affected. Hamstring injuries are slow to heal and prone to recurrence.

Bursitis at the hip

Overuse may also cause bursitis at the hip, and three sites are relatively common:

- The greater trochanter: the bursa lies between the femur at the widest point of the hip and the fascia of the iliotibial band which travels down the outer side of the thigh to below the knee. Adduction of the hip compresses the bursa. This can be caused by running on a cambered road or the distortions of movement caused by flat feet. Pain will be felt on the lateral hip, and may travel down the outer leg. Active and resisted abduction of the hip will elicit the pain.
- The iliopsoas bursa: this has been mentioned in relation to iliopsoas muscle inflammation.
- The ischial bursa: this bursa, at the ischial tuberosity, can suffer direct trauma, usually from a fall, and overuse, commonly caused by running, can trigger the problem.

Bursitis will normally respond to rest and to an adjustment of activity that avoids irritation of the painful site.

The elderly patient

Older patients become doubly vulnerable because there is an increased tendency to fall, and because the proximal femur and the pelvis weaken in their ability to absorb such shocks. Reduced activity means that the elderly are less likely to suffer the muscle tears of the younger adult.

- Elderly patients with hip or pelvis fractures will not routinely present to MIUs. The more severe hip fractures and patients who have spent some time on a floor usually arrive in the emergency department (ED) by ambulance.
- However, undisplaced hip fractures, and some pelvis fractures, can be more subtle and less disabling. A patient may self-present to an MIU with a history of a fall and a subsequent limp. The patient's ability to walk, and the fact that movement is still present to some extent at the hip, may lull you into discounting the likelihood of fracture. If you do decide to request X-rays of the hip and pelvis you may see no fracture. Do not be completely reassured by a negative X-ray. If the patient continues to have pain around the hip a second X-ray a week or so later may show a fracture which was not apparent on the first image.
- These situations can be complex and consultation with senior doctors is often required. A medical event may have caused the fall. You must consider the social background for a patient who is no longer able to walk properly. The difficulty may be increased by a lack of reliable history or by a complex medical history and by the interactions of a large number of medications. The patient may minimise the issue because he or she is afraid of admission to hospital. Dementia may be a factor.
- On occasion an elderly person is brought to an MIU after a fall, perhaps with signs of an injury to the wrist or shoulder. It may be that since the fall the patient has not tried to walk and the signs of a hip or pelvis fracture have not been noticed. Survey vulnerable patients from head to foot and make sure that they can walk before discharge.
- Patients who have prosthetic hips may suffer dislocation. Reduction requires an ED team for analgesia, anaesthesia and manipulation.
- There are a wide range of diagnostic possibilities for elderly patients with hip or groin pain who have not been injured and a medical review is appropriate, especially if the symptoms are new.

Chapter 10

The knee

CONTENTS

INTRODUCTION

Human weight bearing, erect, versatile, dynamic, two-footed and adapted to every solid surface on earth, requires a stable knee (Fig. 10.1). Images of the distal femur, its two knuckles wobbling on the barren surface of the tibial plateau, are therefore unexpected. The fibula is not a part of the joint, tucked away below the lateral condyle of the tibia. The fourth member of the bony assembly, the patella, is a sesamoid implanted in the quadriceps tendon and it does nothing to reduce the impression that these bones are loosely assembled and casually associated, the opposite of a stable relationship. The elbow is the comparable joint in the arm, a limb which is much more mobile than the leg, and yet the bony structures of the elbow are more stable and the joint has less mobility than the knee. The knee is less stable because it requires rotation: the elbow does not require rotation because the forearm is much more mobile than the lower leg, with 180 degrees of pronation and supination and, in fact, this forearm movement can only occur because the elbow is relatively rigid to support the movements of the radius.

And yet the knee is, as it has to be, a stable joint: the stability is provided by its soft tissues. In particular it is held together by a powerful strapping of ligaments around the edge and inside the joint (Figs 10.1–10.3). These ligaments withstand ordinary stresses but if they are torn the knee can be destabilised. A lining of adapted cartilage called meniscus (see Fig. 10.2), which lies on the tibial plateau, also enhances the stability of the knee. It deepens the articulation with the knuckles, the condyles, of the femur and absorbs and distributes the weight which passes through the joint from the trunk. Once again, the meniscus is strong but troublesome if torn.

Powerful muscles that pass around the knee on all surfaces add to its stability, and, in particular, the hamstrings reinforce the anterior, and the quadriceps the posterior, cruciate ligaments (see Figs 10.5 and 10.6 below).

The joint has a small but important capacity to rotate. Its main movements are flexion and extension, often while weight bearing and always in coordination with the movements of the hip, ankle and foot, with which joints the knee shares muscles.

The knee can suffer injury in all of the usual ways but it is particularly vulnerable to destabilising injuries of the soft tissues of the joint. It can be attacked from all four sides and often is during sports like rugby and football. It is often put under undue pressure while carrying the weight of the body or while in extreme positions (such as the forced extension which occurs during a sliding tackle at football). It may, therefore, suffer violent angulations. Injuries which include an element of rotation can be particularly destructive to ligament and meniscus.

ANATOMY

Femur

The shaft of the femur is angled inwards to the knee from the hip and expands into two large bulbous **condyles** at its distal end. The lateral and medial condyles curve backwards behind the line of the bone and outwards to either

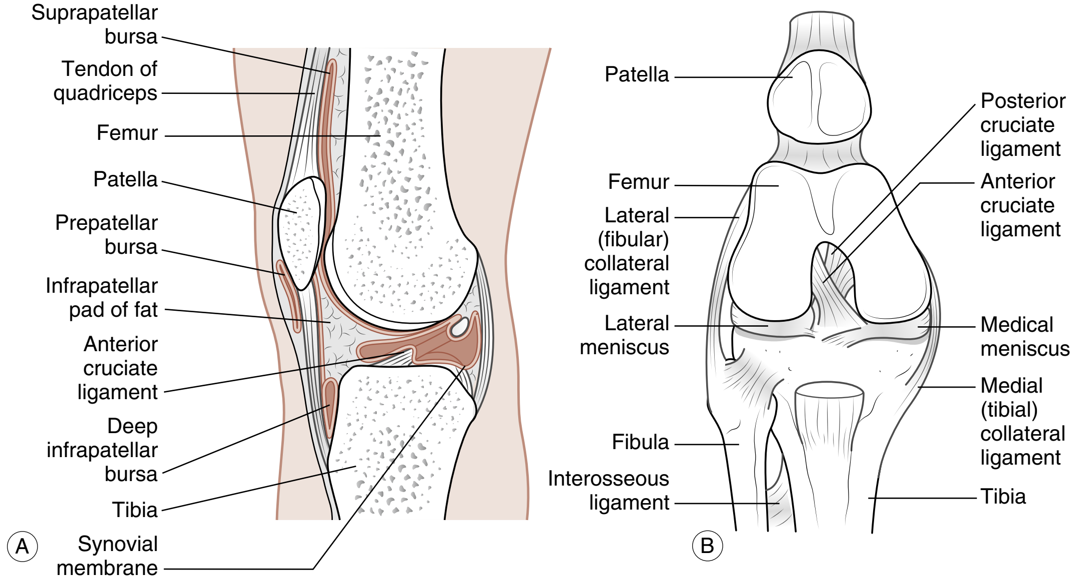

Fig 10.1 The knee joint. A, Section through the left knee from the side. B, A front view with the patella tendon cut and the patella displaced to show the underlying structures.

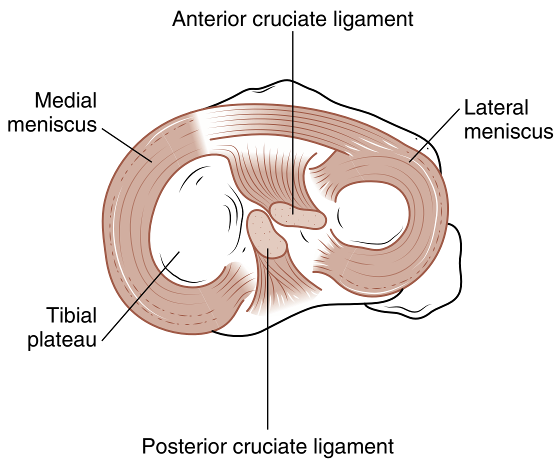

Fig 10.2 The tibial plateau showing the menisci and the tibial insertions of the cruciate ligaments.

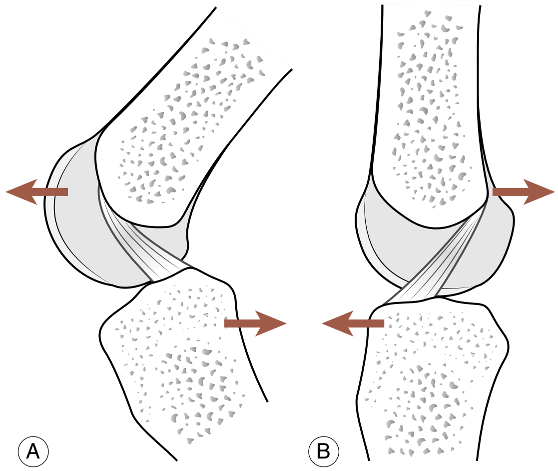

Fig 10.3 The cruciate ligaments limit rotational strain at the knee. A, The posterior ligament prevents slippage forward of the femur on the tibia, especially in a flexed knee. B, The anterior ligament prevents posterior displacement on an extended knee.

side. The condyles are coated with articular cartilage over a much larger area than that which touches the tibia at any one moment. This allows smooth contact over the whole range of movement. The front of the femur has a **patellofemoral groove** between its condyles, which articulates with the **patella** as it moves up and down during flexion and extension. This surface is covered with cartilage. Between the condyles on the back and underside is a hollow, the **intercondylar fossa**, which allows passage of the cruciate ligaments and their attachment at their upper ends.

Tibia and fibula

The tibia and fibula, the two long bones of the lower leg, are linked along their length by ligament and fascia in a manner resembling the radius–ulna pairing in the forearm. However, in the leg the unit is much less dynamic. The fibula plays no part in the knee joint except as an

attachment point for structures like the **lateral collateral ligament**. It has a greater role at the ankle joint. The tibia is the larger bone and the main weight bearer of the lower leg. At the knee it presents an expanded, very flat superior surface, which, like the femoral condyles, projects backwards behind the line of the shaft. This is the tibial plateau. It articulates with the condyles of the femur. Seen from above, the tibial plateau (see Fig. 10.2) has two irregular areas, one on the medial side and one on the lateral, which are the top surfaces of the **medial** and **lateral condyles** of the tibia. The medial and lateral menisci lie on these plateau surfaces and articulate with the condyles of the femur. Also on the plateau is a central ridge between the meniscal surfaces, called the **intercondylar eminence**. In the central area of the plateau, at the front, the **anterior horns** of both menisci are attached, as is the lower part of the anterior cruciate ligament. Similarly, the **posterior horns** of the two menisci, and the lower attachment of the posterior cruciate ligament, are attached to the back of the tibial plateau in this central area. In front of the tibia in the midline, just distal to the plateau, is a bulge called the **tibial tuberosity**, which is the insertion point of the tendon (sometimes called the ligament) of the patella. This is the point which offers attachment at the lower leg to the whole **extensor mechanism** of the quadriceps. From the front, the two condyles of the tibia can be seen bulging out to either side, beyond the line of the shaft of the tibia.

Patella

The patella is a sesamoid bone, offering a focal point for the forces exerted by the quadriceps muscle before they are transmitted to the lower leg. It is of variable shape. It tends to be roughly oval, but with a flattened top and pointed base. On its patellofemoral surface, it is thickly coated with cartilage to withstand the tremendous forces to which it is subjected during, in particular, weight-bearing flexion and extension of the knee.

Meniscus

The menisci (see Fig. 10.2) are similar in makeup (collagen with a small amount of elastin) to ligament. They lie on the tibial plateau, one medial and one lateral. They are crescent shaped, with their openings facing towards the central ridge of the plateau and each other. They deepen the articular surface of the tibia for the femoral condyles. They are shock absorbers. They stabilise and guide the movement of the femur on the tibia. The pulling and compressing forces in the joint can cause tears in the meniscus, especially during rotation. No extreme movement is necessary to tear the meniscus, and the mechanism of injury can seem slight to the patient.

The menisci have virtually no blood supply and they do not heal when torn. This means that tears can become chronic, worsening problems for the patient, characterised by episodes of pain and swelling and by 'locking', a sudden blockage of movement, usually extension, caused by displacement of a damaged fragment of meniscus.

Collateral ligaments

The knee has two **collateral ligaments** (see Fig. 10.1), one **lateral** and one **medial**, which fasten the femur to the head of the fibula on the outer side and to the tibia on the inner side. The medial ligament has a deep layer which is joined to the medial meniscus, and it can be difficult on examination to discriminate between injury to one or the other; indeed, sometimes they are both injured (the 'unhappy triad' is a combined injury to the medial ligament, meniscus and anterior cruciate ligament caused by a violent valgus stress to the knee). These ligaments take a part in stabilising the knee, but their main function is to limit varus and valgus movement, respectively. They are usually injured by a blow to the opposite side of the knee during sport.

Cruciate ligaments

The **anterior** and **posterior cruciate ligaments** are so called because they cross in the middle of the knee joint (Figs 10.1–10.3). Each one prevents slippage of the tibia on the femur; by tightening around each other during movement, they also limit the range of internal rotation. The anterior cruciate travels from the front of the tibia, on the medial side, to the rear lateral condyle of the femur, to which it is joined on its medial side. It tightens as the tibia is pulled forward from under the femur, and this is the movement which it limits. The posterior cruciate, travelling backwards from the lateral side of the medial condyle of the femur and inserting into the rear edge of the tibial plateau, slightly to the outer side, limits the reverse movement, backward slippage of the tibia on the femur.

Bursae

There are a large number of bursae around the knee. The one which commonly causes symptoms is the **prepatellar bursa**, in front of the patella. Prepatellar bursitis is widely known as **housemaid's knee**. The **infrapatellar bursa** which is directly below the patella at the patellar tendon can also become inflamed, a condition known as **clergyman's knee**. Both of these bursae are superficial and inflammation causes the skin to become red, with heat, prickly tenderness and swelling.

EXAMINATION

Look

A swollen knee will cause the patient to walk in the loose-packed position of the joint to accommodate fluid, an

equinus gait, on the ball of the foot with the knee and hip slightly flexed. This gait may also be adopted to prevent painful stretching of injured soft tissues. A patient with a locked knee may limp in a similar way because a torn, displaced meniscus is obstructing full extension of the joint. If this is the case the patient may need surgery. The cause of a loss of extension is often the first question which you will try to answer during examination of the knee. Whether or not the joint is locked, an equinus gait is tiring, potentially unstable and stressful to other parts of the body. Consider a walking aid to improve movement even if the patient is 'mobile'.

A patient who limps on a straight knee, swinging the whole leg from the hip, may be immobilising a symptomatic patella. A patient who cannot raise the injured leg onto the trolley, and who passes the uninjured foot under the other ankle to lift the leg, may have a rupture of the extensor mechanism.

With the patient comfortable on the trolley, compare the two knees front and back. Standard signs of injury include wounds, swelling, bruising, redness and deformity. The question of whether or not there is an effusion in the knee is often only answerable by looking at the two knees together. Swelling is first seen in the medial hollow of the knee, on the inner side of the patella: a larger swelling will also show in the suprapatellar area. Sweeping a hand upwards along the inner side of the knee can show that fluid from a smaller effusion is present: the fluid is carried up into the suprapatellar area and is visible returning to the medial hollow. Ask how quickly the swelling developed: a swelling which developed within minutes of injury rather than hours is likely to have been caused by bleeding, a **haemarthrosis**. The presence of a haemarthrosis is a pointer to a possible severe injury although it does not indicate a specific diagnosis. Blood is undesirable in a joint and limits movement, but aspiration carries the risk of infection and, on the whole, it is avoided in favour of conservative measures such as ice and elevation to reduce the swelling. A localised, soft swelling anterior to the patella, with redness, heat and tenderness, may be a prepatellar bursitis. Check the patient's temperature and assess the possibility of infection.

Muscle wasting caused by injury or disease develops quickly in the knee: the inner quadriceps muscle, which has a characteristic bulge above the medial, upper patella, is quick to diminish. You can use a tape measure to compare the girth of the muscles. Be careful to measure the two legs at precisely the same level and in the same position. The upper margin of the patella is a useful landmark.

A Baker's cyst may be seen in the popliteal fossa.

Feel

On palpation, assess the patellofemoral joint with the knee straight, and assess the menisci, at the tibial plateau, with the knee in flexion at approximately 90 degrees. The popliteal area should be assessed with the patient lying prone.

Examine the patella with the knee in full, relaxed extension, so that it is not held tight against the femur by the quadriceps. It can be tilted and palpated on its articular surface from both sides, and it can be compressed against the femur to assess the smoothness of the patellofemoral contact. Always compare the two knees. Patella tracking should also be felt during flexion and extension, looking for clicking or grating, but once again comparing to the uninjured side. A normal patella can click, especially if compressed during movement.

Ask the patient to bend the knee to 90 degrees of flexion. This position may feel 'tight' if there is swelling (while, if the excess fluid presses against a fracture, pain will be the complaint rather than tension). The patella will now be held immoveable against the femur, but the patella tendon below it will be firm and easily palpated from the lower tip of the patella down to the bulge of the tibial tuberosity. Place two fingers on either side of the tendon and press into the knee and downwards. Your fingers will contact the edge of the tibial plateau, crowned by the front borders of the menisci. The meniscus is more easily felt if the knee is rotated, laterally for the medial side and medially for the lateral. Feel round to the inner side where the medial collateral ligament crosses the joint line from the adductor tubercle of the femur to the medial tibia below the joint. The ligament can be known by its location but it lies too close to the joint to be felt separately. Tenderness on the joint line itself, where the ligament is joined to the meniscus, may arise from meniscus or ligament, or sometimes from both. The lateral collateral ligament can be similarly felt on the outer side. Its femoral insertion lies further back than on the medial side, and it inserts below into the head of the fibula, which can be felt as a distinct bulge on the lateral side of the tibia. The lateral collateral ligament is palpable, especially with the leg in a 'figure-4 position' (with the outer ankle of the injured leg lying across the other shin and the knee bent). The ligament in this position feels like a bone-hard ridge rising from the head of the fibula, but it reveals its softness when the knee is moved.

With the patient prone the tendons of the hamstrings can be seen and felt, enclosing the posterior hollow of the knee, the popliteal fossa. There is a good deal of muscle in the hollow, but there is also potential for joint swelling. A Baker's cyst can be seen and felt in that region. Bursitis may cause tenderness, especially at the medial hamstring tendons.

Move (Figs 10.4–10.12)

It is common for a patient with an injured knee to avoid full extension, behaviour that may indicate swelling, or that the knee is mechanically obstructed by torn meniscus, the

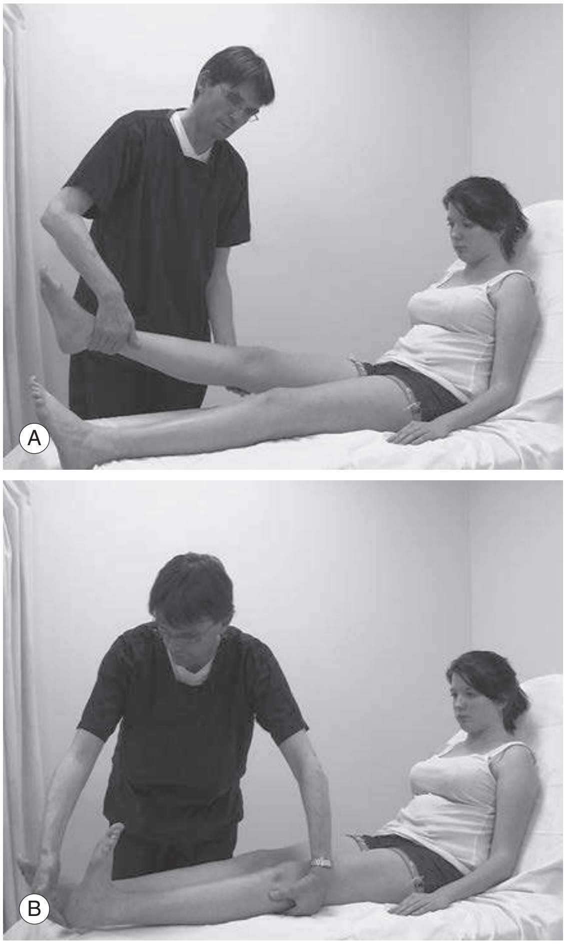

Fig 10.4 A, Passive extension of the knee. Does the knee extend fully? Is the endfeel firm, or is there a springy obstruction? B, Active extension of the knee. Dorsiflex the foot to expose any hypertension in the knee. Compare the two sides to decide what is normal for the patient.

condition known as locking. Your examination will begin with an evaluation of the patient's extension.

With the patient face-up on the trolley ask him or her to dorsiflex the ankles and push the backs of the knees down into the trolley: some patients have a marked hyperextension of the knees and you cannot be sure that a knee is attaining full extension even if it lies straight on a trolley. In this position any amount of heel-lift from the trolley is hyperextension and if either heel rises they should both rise equally. Continue your assessment by comparing the endfeel of passive extension on both sides. Lift the leg by the heel with one hand, put your other hand under the knee, lift it into a few degrees of flexion and drop it so that it thuds softly into full extension in your palm. You should both feel and hear the solid, ligamentous endfeel of normal knee extension. If the endfeel is felt before full extension, if it is soft or has a rubbery rebound, then the knee may be blocked by torn meniscus, or by another material mimicking a meniscal injury (a 'loose body'). If you remain uncertain that the patient is attaining full extension, ask him or her to lie prone with both feet hanging off the end of the trolley. Gravity and relaxation (perhaps with the help of analgesia and nitrous oxide) should combine to extend the knees fully so that the backs of both heels are at exactly the same height, unless there is locking.

Once you have 'cleared the joint', assess the muscles of extension. Ask the patient to raise the straight leg from the trolley to demonstrate that the extensor mechanism is intact, pass a hand under the knee, resting it on the opposite knee, and put the other hand on the raised shin. Say to the patient 'don't let me bend your knee' and press down on the shin, trying to bend the knee around your lower forearm. This is a resisted test of the quadriceps muscles.

Ask the patient to actively flex the knees by bringing the heels as close to the buttocks as he or she can manage without using the hands. Compare the position of the backs of the heels on the trolley to measure flexion in the injured knee. Passive flexion will increase the range by pressing the calf into the back of the thigh, a soft endfeel. Resisted flexion is tested by asking the patient to bend the knee to 90 degrees, palpate the tendons of the hamstrings with one hand, put the other hand on the back of the heel and say 'don't let me straighten your knee'.

Check that the knee is passively free to rotate. With the patient face-up, bend the knee to about 90 degrees with the lower leg resting on the point of the heel. Hold the foot so that you control the ankle and rotate the lower leg laterally and medially: watch the shin and see that it moves side-to-side. For lateral rotation put your thumb web over the front of the ankle and turn the foot outwards. For medial rotation put your palm on the lateral edge of the foot and turn it inwards. Put your free hand on the tibial condyles so that you can feel rotation and also whether there is any resistance or clicking in the joint. Some patients have mainly lateral rotation, with very little medial: others are equal on both sides.

Four ligaments are subjected to passive stress-testing in the knee, checking for pain and laxity. Collateral ligament tests are always performed in the same way. Put one hand on the opposite side of the joint to the ligament. Put the other hand on the same side as the ligament, but near the distal end of the limb or digit. Push through the joint with the first hand and pull towards yourself with the second one so that the ligament is stretched. In the knee these tests are done on the lateral and medial sides with the knee in slight flexion. If the medial collateral ligament is lax in flexion, extend the joint and retest. Laxity in full extension suggests a grade 3 tear of both layers of the ligament. There is usually slightly

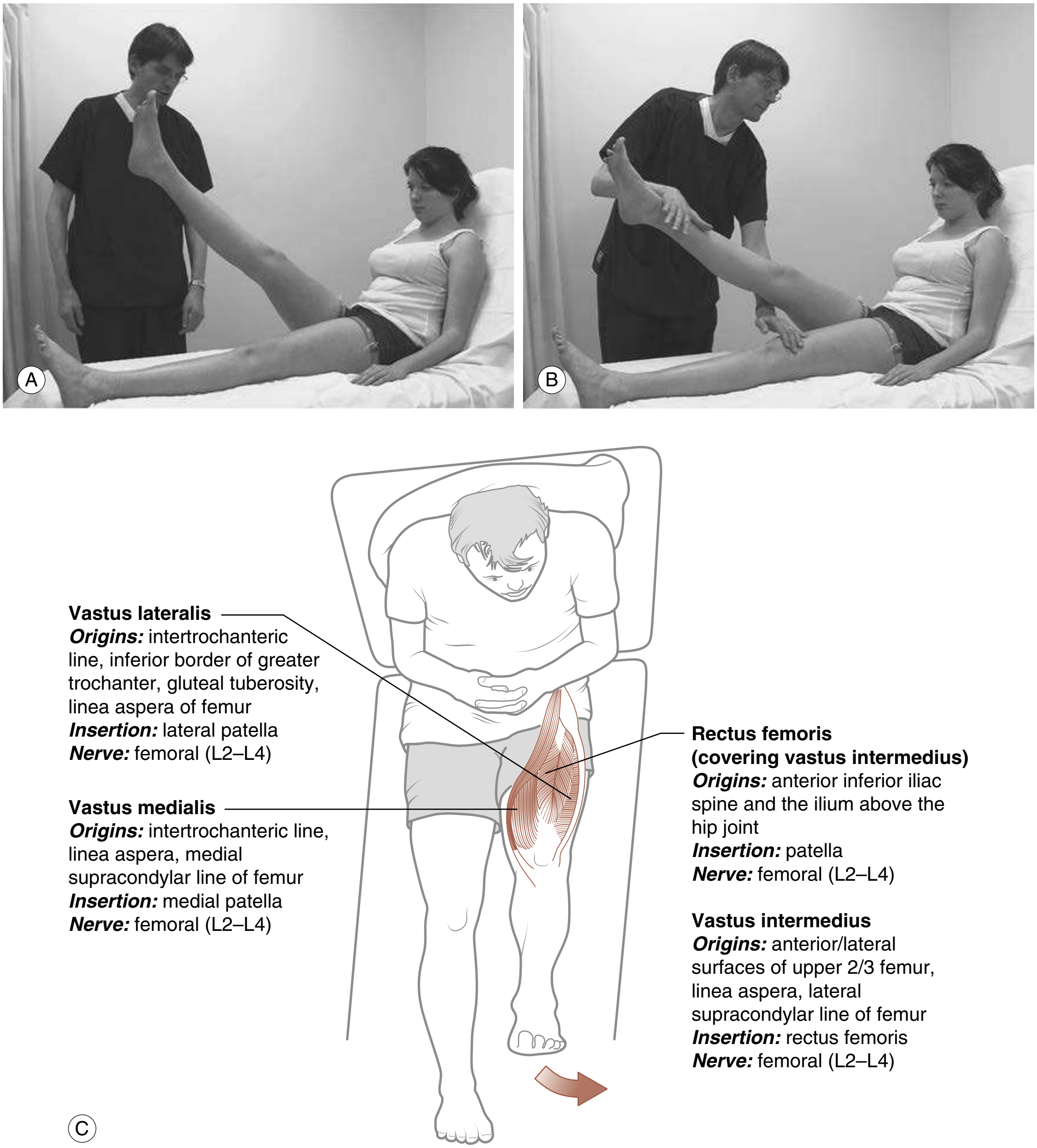

Fig 10.5 A, Straight leg raise shows good function of the extensor mechanism. B, Resisted extension of the knee. C, Extensors of the knee.

more laxity in the normal lateral collateral ligament than the medial. To stress the cruciate ligaments, the examiner pulls the tibia forward and pushes it backwards from under the femur, the anterior and posterior drawer tests respectively. Ask the patient to bend the knee to 90 degrees. Sit on the trolley facing the patient with your bottom blocking his or her foot so that the force of your pull makes the knee glide rather than extend (mention that you are going to do this: patients find someone flopping onto a foot more invasive than we sometimes realise). For the anterior drawer test

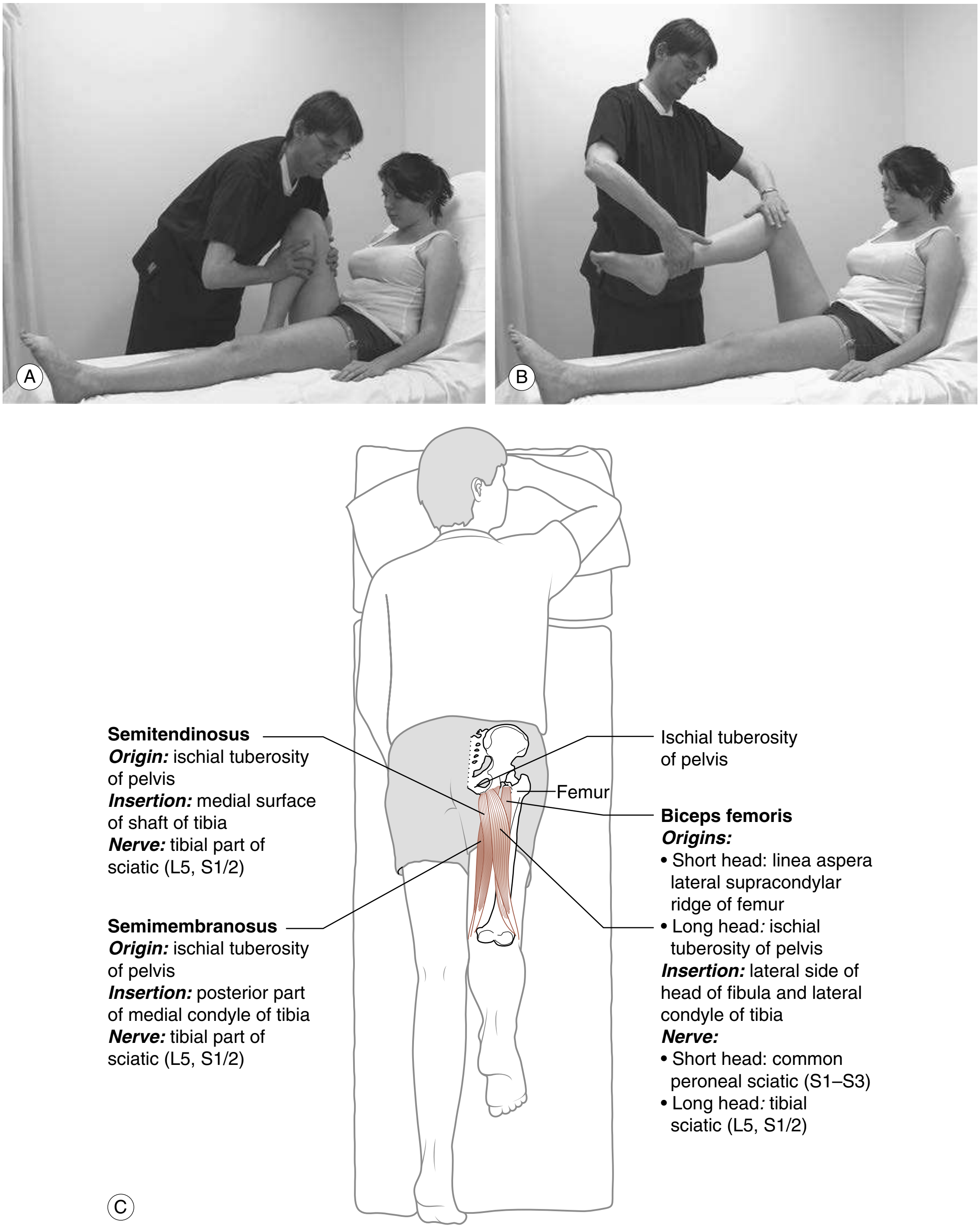

Fig 10.6 A, Active flexion of the knee. If the patient has a full range, passively overpress the knee to clear the joint. B, Resisted flexion of the knee. C, Flexors of the knee.

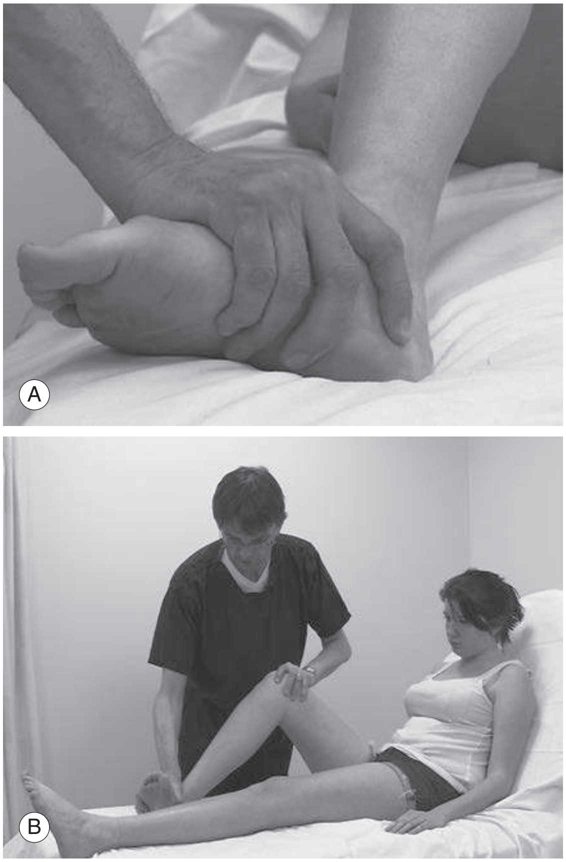

Fig 10.7 A, Passive lateral rotation of the tibia at the knee. B, Passive medial rotation of the tibia at the knee. Note the tester's hand positions. Feel the knee and watch the shin to ensure that foot is not rotating instead of lower leg.

remember that if the hamstrings are tense the muscle may conceal laxity of the anterior cruciate ligament. Use your index fingers to monitor the tendons of the hamstrings; press up into them and ask the patient to keep them relaxed; put your thumbs on the tibial condyles and your other fingers round the calf; straighten your elbows so that you use your body weight rather than your arms, and lean back. Assess the glide of the tibia. A tiny amount is normal for some patients: a large movement, especially with grating, is abnormal. Compare the result to the uninjured knee. For the posterior cruciate ligament, leave your non-dominant hand in the same position as for the anterior cruciate test, put your dominant hand on the tibial tuberosity, straighten your elbow and push the tibia backwards with your body weight. Note that when a patient has a large posterior tear the tibia may drop gravitationally into a lax position when the knee is bent to 90 degrees. The test may seem deceptively normal. Look at the profile of the two bent knees before

Fig 10.8 Stress of medial collateral ligament. Pressure is applied to lateral knee to stress medial side. Patient has to relax with knee in slight flexion. Pain or laxity is positive.

Fig 10.9 Stress of lateral collateral ligament. The reverse of Fig. 10.8.

testing to ensure that the lower legs are in the same position in relation to the upper. An occasional error in testing the posterior cruciate ligament is putting the hand too high, on the femur, stressing the hip instead of the knee.

A further test of the meniscus is part of the basic knee examination. This test, called the McMurray's test, is simple in conception but difficult to do. The key idea is that compression of the knee joint will increase and elicit meniscal symptoms. The knee is compressed by pressing down with one hand on the knee and pushing upwards through the heel with the other. With this compression maintained,

Fig 10.10 Anterior cruciate drawer test. Knee flexed to approximately 90°. Stabilise it by sitting on the patient's foot. Ensure that hamstrings are lax by putting index fingers against them. Put thumbs on knee joint line to feel any laxity. Use hands on calf to pull tibia forward; lean back with straight arms to ensure good power. Compare both sides. Laxity or pain is positive.

Fig 10.11 (See Fig. 10.10.) Continue by testing posterior cruciate ligament. Support tibia at calf with one hand (to ensure that, if the posterior cruciate is lax, the tibia has not already fallen backwards). Use the same thumb to feel the joint line. Put the other hand on the tibial tuberosity (it is a common fault to place the hand over the patella). With arm straight, push the tibia backwards. Feel for laxity. Compare both sides.

the joint is then rotated continuously, moved from a varus through to a valgus position and back again repeatedly, and taken from flexion to extension, all at the same time, so that every accessible corner of the tibial plateau will be stressed against the femur, and any irregularity in the surface will show as grating or clicking. It is often not necessary, or possible if the knee is very restricted, to use McMurray's to

Fig 10.12 The McMurray's test for meniscal obstruction. This is a difficult test to perform. The joint surfaces are tested by grinding them against each other in every position they can attain. The knee moves passively in: 1. Compression of tibia against femur. 2. Full flexion to almost full extension. 3. Lateral–medial–lateral rotations of joint. 4. Lateral–midline–medial angulations of joint. Pain alone is not a positive result. Grating or clicking in the joint is positive.

Box 10.1 **Knee statistics**

- Capsular pattern: greater loss of flexion than extension, with no loss of rotation.
- Joint positions: loose packed in midflexion; close packed in full extension.
- Flexion 0–140°; endfeel tissue approximation of calf on hamstrings.
- Extension 0° but 10° of hyperextension possible; endfeel firm, posterior capsular stretch.
- Rotation of tibia 0–30° medial, 0–40° lateral; endfeel firm, capsular and ligament stretch.

diagnose a meniscal tear, but it is an excellent test to demonstrate a valuable negative finding, that the meniscus can withstand this searching examination.

The peroneal nerve passes down the fibula from the popliteal knee, and fulfils a similar function to the radial nerve in the arm, supplying sensory fibres to the outer side of the dorsal foot and motor fibres to the extensor muscles at the ankle. It is surprisingly easy to overlook a motor deficit in the peroneal nerve (presenting as a 'dropped foot'). The foot tends to lie in plantar flexion on an examination trolley, and an equinus limp can perpetuate the disguise when the patient is moving. The assessment of this nerve should be part of he routine neurovascular assessment of the lower leg after injury to the knee. Stand at the foot of the trolley. Assess sensation

Box 10.2 A suggested routine for a knee examination

Observe the patient's gait. Is there a 'lag'? (Is he walking on the ball of his foot to avoid straightening his knee?)

- Ask the patient to expose both legs from thigh to foot.
- Ask the patient to lie supine on a trolley and to extend both knees.
- Assess distal sensation and circulation.
- Assess the peroneal nerve, check sensation on the lateral foot, and resisted dorsiflexion of the ankle.
- LOOK for swelling, redness, bruising or deformity. Is there an effusion (most clearly seen in the medial hollow and suprapatellar areas)? Did it develop within moments of injury (a haemarthrosis) or more slowly? Is there wasting of the thigh muscles? Is the patient avoiding full extension of the knee? On the back, is there popliteal swelling?
- FEEL the patella and move it in the femoral groove with the knee extended and relaxed. Feel the quadriceps. Flex the knee to 90° to feel the joint and related structures. Feel the tibial tuberosity and the patellar tendon. Move laterally over the lateral meniscus and femoral condyle, the lateral collateral ligament and the head of the fibula. Assess the medial meniscus and femoral condyle and the medial collateral ligament. Feel the popliteal fossa and the tendons of the hamstrings.
- MOVE (these tests are shown in Figs 10.4–10.12). Passive extension of the knee will clear the joint. Note the endfeel. A displaced meniscal tear will have a springy endfeel. Active and resisted extension will assess the quadriceps and patella. Assess active, resisted and passive flexion. Assess rotation passively. Stress four ligaments by stretching them, look for pain or laxity. If you suspect meniscal locking, the McMurray's test is designed to assess the joint surfaces by compressing them and moving them against each other.

on the lateral dorsum of the foot, compared to the opposite foot, by light touch. Ask the patient to dorsiflex the ankle. Put your hand on the dorsal foot and say 'don't let me pull your foot towards me'. If you are in doubt, compare with power on the other side.

Box 10.2 summarises the routine for a basic knee examination.

Fig 10.13 AP view of the knee.
Source: From Carver, E., Carver, B., 2012. Medical Imaging: Techniques, Reflection & Evaluation, second ed. Churchill Livingstone.

Fig 10.14 Lateral view of the knee.
Source: From Carver, E., Carver, B., 2012. Medical Imaging: Techniques, Reflection & Evaluation, second ed. Churchill Livingstone.

X-RAYS (FIGS 10.13–10.15)

The Ottawa group has published guidelines for the requesting of X-rays when the knee is injured. Key recommendations are that patients over 55 years old, those with isolated tenderness of patella or head of fibula and those who cannot flex the knee to 90 degrees or walk four steps require X-rays. In general, among patients with minor injuries to the knee,

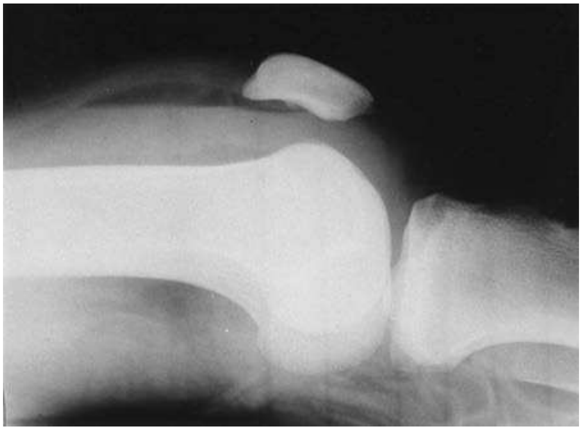

Fig 10.15 Lipohaemarthrosis.
Source: From Mitchell, P., 1999. The assessment of acute knee injuries by Senior House Officers in the Accident and Emergency Department. Injury 30(3), 215–218.

fractures are not common: the majority of injuries are to soft tissues. Certain injuries which do not immediately suggest the idea of fracture require X-ray: patients with meniscal symptoms are X-rayed to rule out a bony loose body in the joint, and patients who have suffered a patella dislocation are X-rayed to exclude an **osteochondral** fracture in the patellofemoral joint. Fractures to the lateral lip of the tibial plateau (a **Segond fracture**) and to the tibial spines in the centre of the plateau, appear trivial and can be overlooked, but they indicate likely significant soft tissue injuries within the joint.

Standard X-rays are the anteroposterior (AP) and lateral with the patient lying down. Occasionally injuries to the patella are not well demonstrated on standard views and an additional view, the so-called oblique 'skyline' view, is requested. It is mandatory if an osteochondral (meaning 'bone and cartilage') fracture from the patella is suspected after a dislocation.

On the AP view the width of the femur and the tibia at the knee joint should be virtually the same. If the tibia projects more than 5 mm beyond the femur on either the medial or the lateral side, a fracture, which may not otherwise be easily seen, may be widening the tibial plateau.

On a lateral view the gap between the bottom edge of the patella and the tibial tuberosity should be approximately equal to the length of the patella: if the gap is greater a rupture of the patella tendon is possible. Return to the patient and compare the two knees. If you have not done so, ask the patient to perform a straight-leg raise.

Certain normal appearances can be mistaken for fractures: the patella does not always complete its ossification process, and some people have a **bipartite patella**, most commonly with a well-corticated separate segment on the upper outer corner. A small sesamoid bone in the outer gastrocnemius tendon, the **fabella**, is often seen at the posterior joint line on a lateral view and mistaken for a fracture or a loose body.

As with elbow X-rays, visible blood in the joint may suggest a fracture when the fracture itself is not seen. The horizontal lateral view will show a dark fluid level in the suprapatellar pouch, blood, topped by a grey layer of fat from the bone marrow. This is called a **lipohaemarthrosis**.

INJURIES

Fractures

The patella is the bone most commonly fractured in minor knee presentations. It is relatively vulnerable to impact injuries compared to the two large bones. A patella fracture may require surgical management if the extensor mechanism is divided. The trauma of a patella dislocation may cause fractures in the patellofemoral articulation, either on the inferomedial patella or the lateral femoral condyle. This injury may only show on a skyline view. This injury is more likely in young patients, where the incidence may be in 8% of dislocations and, especially with a femoral injury, may cause significant later problems.

The spines in the midline of the tibial plateau are attachment sites for the cruciate ligaments and are occasionally avulsed when the ligament is injured. This is more likely in an adolescent than an adult.

On the AP view a small avulsion fracture at the lateral tibial plateau, called a Segond fracture, can accompany anterior cruciate ligament or a meniscus tear. Varus angulation of the knee with medial rotation of the lower leg is the usual mechanism of injury.

A fracture of the proximal shaft of the fibula may be part of a larger injury to the soft tissues of the knee or to the lower leg, with possible injury to the syndesmosis at the ankle and rupture of the medial deltoid ligament or fracture of the medial malleolus. This combination is called a Maisonneuve fracture.

Fractures of the tibial plateau, much more common on the lateral side, are depressed injuries cause by a downward impact from the femoral condyle against the tibia. A valgus force from an impact to the outer knee, sometimes caused by a car bumper, is the most common mechanism. There may be widening of the plateau in relation to the femur on an AP X-ray, and a dip in the surface of the tibial plateau compared to the medial side. The knee may remain in a valgus deformity. Impaction may show as a sclerotic line on the proximal shaft of the tibia. This is a severe injury which usually requires surgical management, but it can be surprisingly subtle on X-ray. However, the severity of the injury

should be apparent clinically with haemarthrosis, pain and inability to walk.

Injuries to the extensor mechanism

A direct blow or a violent contraction of the quadriceps may fracture the patella, tear the quadriceps tendon, the patella tendon or avulse the tubercle of the tibia. The patient may divide the patella tendon by striking the flexed knee against a hard edge, perhaps a low wall. A similar mechanism can divide the quadriceps tendon. The patient will be unable to extend the knee or do a straight leg-raise on the examination trolley. You may notice that he or she lifts the leg passively by passing the other foot under the ankle of the injured leg. On X-ray the patella may be higher than normal if a ruptured patella tendon no longer restrains it: a division of the quadriceps tendon may result in the opposite effect. In both cases it is common to be able to feel a defect in the tissue.

This injury will require surgical repair of the divided tissue to restore the extensor mechanism.

Osteochondritis dissecans

In adolescence a fragment of bone and hyaline cartilage may detach from the lateral aspect of the medial femoral condyle, causing pain and swelling, and occasionally the locking symptoms caused by a loose body obstructing the joint. X-ray will usually show the defect: refer the patient for orthopaedic assessment.

Patella dislocation

The patella is a sesamoid bone planted in the tendinous and joint capsule tissues at the front of the knee where the quadriceps muscles unite and attach to the front of the tibia. It ascends within a groove at the front of the femur between the condyles as the quadriceps muscles contract to extend the knee and it descends during flexion of the joint. The quadriceps muscles lie on the diagonal shaft of the femur, and their upper origins are lateral to the knee. There is a tendency for the pull of the muscles to carry the patella outwards as well as upwards, a tendency counteracted by, among other things, the medial quadriceps muscle, the vastus medialis. Any factors which increase the tendency of the patella to move laterally may lead to dislocation to the outer side. The problem is more common in females because a wide pelvis increases the oblique angle of the femur. It is also a feature of growth, because bone growth is followed by a phase of muscle tightness which may take the patella high enough to slip out of its groove. Other factors, a few of many, which may predispose to this injury include hypermobility, an abnormally high patella (patella alta) and a shallow patellofemoral groove. Lateral displacement injures the restraining medial quadriceps and tears the retinaculum, the fibrous band which attaches to the medial patella. This creates a vicious circle by making the already unstable patella less well supported. There is also a risk of fracture and cartilage injury to patella or femur in the patellofemoral area where much of the violence of the injury is felt, and you should request X-rays of the knee, including a skyline view. Any person with a normal patella may suffer a traumatic dislocation from an impact across the front of the knee from the medial side. This will be accompanied by severe pain and a haemarthrosis. The patient may require reduction of the dislocation if this has not occurred spontaneously. This is simple to do if the patient is able to tolerate it, by applying pressure in a medial direction to the lateral edge of the bone. This injury often recurs, but may settle when growth is complete. Care will usually involve a combination of orthopaedic assessment and physiotherapy. There are surgical options but these will only be considered if it is clear that the problem will not settle. It is vital for patients with patella problems to maintain strong muscles around the knee.

Osgood–Schlatter disease (Box 10.3)

During growth the patella tendon can pull excessively on the soft apophysis of the tibial tuberosity and cause the physis to widen and to become painful during exercise. This problem, generically known as **traction apophysitis**, afflicts sporty children and it can occur in a variety of sites in the arm and leg depending on the types of sport that the child engages in.

Clinically, there will be enlargement of the tibial tuberosity, a feature which will remain as a reminder of the problem. It settles when the patient is fully grown.

Ligament tears

A violent angulation or rotation, a blocking blow to the front of the tibia (such as hitting a car dashboard in a crash) or a violent hyperextension may tear one or more of the ligaments in the knee. The history will normally be of a very painful injury, and the more severe injuries may be

Box 10.3 Osgood–Schlatter disease

- A traction apophysitis (meaning, a pull on the bony insertion of a muscle which widens the growth plate and causes pain) found in athletic teenagers, whose patella tendon stresses the tibial attachment.
- There is typically pain on exercise and a local swelling.
- Settles with rest. Permanently settles when the skeleton matures.

accompanied by haemarthrosis and fractures. It is, however, possible to have a large ligament tear in the knee with very little swelling. The knee may be unstable in a varus/valgus direction (collateral ligaments), anterior/posterior direction (cruciates), or there may be rotational subluxation. When examining a patient with a history of injury to the knee, you will routinely stress the two collateral and the two cruciate ligaments, looking particularly for signs of laxity. Grade 3 cruciate tears require orthopaedic review; they will not heal and may require surgery. Valgus impact to the outer knee, a common event in sport, will open the inner side of the knee and can cause a sequence of tears to the medial collateral ligament, the medial meniscus and the anterior cruciate ligament, a combination known as the 'unhappy triad' (described above).

Meniscus

The usual mechanism by which the meniscus is torn is rotation of the knee, particularly while flexed and weight bearing. There is also potential for combined injuries at the medial knee where the meniscus is attached to the medial collateral ligament. Meniscus injury often happens at football, hockey, skiing and other sports. The mechanism of injury will be painful but not necessarily involve an abnormal movement: this is a useful discriminator between a meniscal injury and a possible ligament tear. Ligaments can only be torn if the joint is forced beyond its permitted range of movement. Meniscal tears are more common at the medial side. There may be obstruction of the joint (locking) by a displaced piece of meniscus, which is chiefly shown by the patient's inability to fully extend the knee; this may resolve itself (sometimes suddenly during examination) if the displacement reduces. If the problem settles, the patient may need to do no more. However, the menisci have virtually no blood supply and tears do not heal. There is likely to be a recurrence of the problem, perhaps repeatedly.

Occasionally a knee will lock in an odd position, perhaps 80 or 90 degrees of flexion, which will make it necessary to try to reduce it immediately for the patient's comfort. It will do no harm to apply traction between the thigh and the lower leg to open up the joint. This will reduce pressure on the torn tissue and usually increase the patient's range of movement. Gentle manipulations of the joint through its range of movement may then reduce the meniscus, something that will usually announce itself by a click. Do not release the knee in a more extended position than you found it and be alert to the patient's comfort throughout the whole process.

Bursitis

The commonest site for bursitis in the knee is the prepatellar area, where the superficial bursa becomes painful, swollen, hot and tender, with vivid redness of the skin. The cause is usually impact or friction, and people with jobs which involve kneeling on hard surfaces are most susceptible. The condition is called housemaid's knee, but in the modern world roofers, plumbers and carpet layers are more common sufferers. Rest, with strict avoidance of further irritation of the site, is the key requirement. People whose jobs involve kneeling should use knee-pads to prevent this condition. Make a careful assessment of all cases to rule out infection. Inflammation of the infrapatellar bursa may present similarly, with redness below rather than over the patella, a condition called clergyman's knee. A patient with bursitis at the front of the knee will find flexion painful because it stresses the bursa, but there should be no difficulty with extension of the knee. If the patient cannot straighten the knee consider whether the problem is in the joint rather than the bursa. In practice this is not usually difficult to determine. There are many other bursae around the knee, all lying deeper than the two described. Inflammation in these will not present with external redness but there will be a history of irritating activity, often sport, and focal tenderness.

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Chapter | 11 |

The lower leg

CONTENTS

INTRODUCTION

The human foot is interesting as a chronicle of evolution, equipped for activities which it no longer performs and slowly losing those attributes as it settles to being encased in leather and pounding the pavements of our modern world. If one looks at the paws, pads and hooves of other creatures, the foot seems unnecessarily complicated and delicate for the job of weight bearing. And if one looks at the prehensile feet of primates, obviously nearer to the human, they seem to be using them in the ways they are 'meant' to be used, whatever that may mean, for activities which involve less impact but greater dexterity, maintaining in them a closer kinship to the hand.

The foot has adapted to be a structure which fulfils two functions, weight bearing and shock absorption. Humans place special burdens on the foot compared to quadrupeds and primates because we walk upright, with the centre of gravity more or less between our feet: we do not delegate any part of weight bearing to the upper limb and we are more averse to climbing than our closest relatives among the mammals.

The emergency nurse practitioner's (ENP's) relationship to the injured foot is limited. The inversion sprain of the ankle is the commonest injury in the world. The daily procession of people limping and hopping through our minor injury units (MIUs) is the defining image of the service. But while, for example, the hand is exposed to a large variety of injuries, open and closed, that require the testing of a variety of delicate functions, the foot is shielded within the shoe and tends to be injured in the same place and in the same way almost every time, and that a relatively straightforward matter of ligament or bone, and grade 1, 2 or 3 if it is, as it usually is, ligament. We therefore tend to have in our heads a rather simple model of the ankle and foot which serves us for almost every case: but we run out of resources very quickly when a patient complains of pain in another part of the foot or when an issue arises from a defect in its dynamics or its posture.

ANATOMY (FIG. 11.1)

Tibia

Below the knee, the shaft of the tibia narrows and is relatively slender until it reaches the ankle joint, where it broadens again. Seen in cross-section, the tibial shaft is triangular, with the base of the triangle at the back of the leg, covered by the calf muscles. The apex at the front is a ridge which curves down and inwards to the **medial malleolus**, the bulging inner ankle. This medial surface of the triangular section of the tibia is the shin. It is superficial from knee to inner ankle. The lateral border of the tibial shaft has an **interosseous border** with the fibula. This side of the bone is clothed in extrinsic muscles of the foot and ankle, which arise from the proximal tibia and fibula. (This is unlike the situation in the forearm, where most of the extrinsic muscles arise from the humerus and cross the elbow as well as the wrist. In the lower leg, only the gastrocnemius and plantaris muscles of the calf cross the knee joint.)

Fibula

The fibula is similarly expanded at top and bottom, with a long, slender shaft between. The head of the fibula

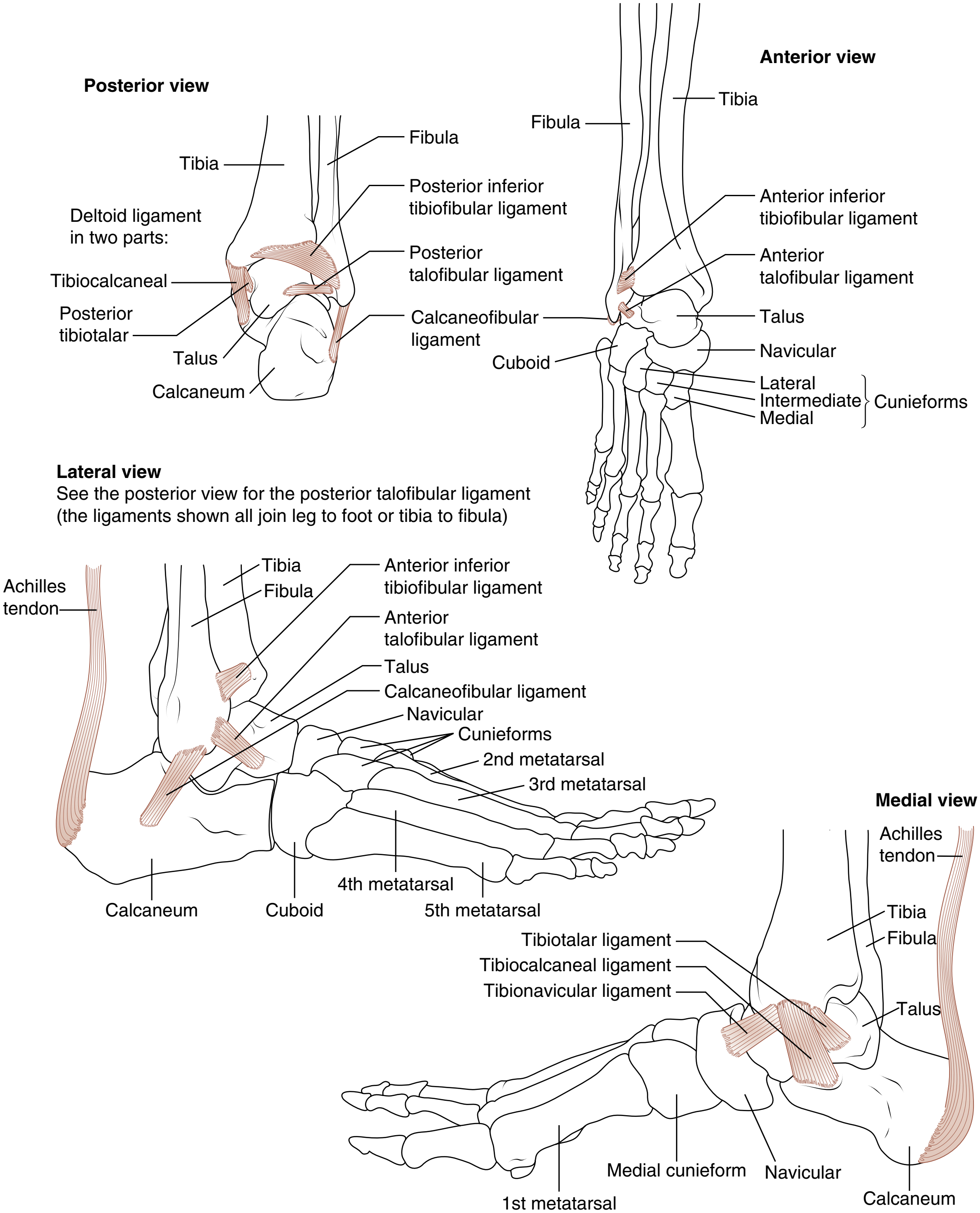

Fig 11.1 The bones of the lower leg, ankle and foot with the main ligaments.

articulates with the tibia on its lateral side, tucked under the bulging lateral condyle and taking no part in the bony articulation of the knee. The shaft passes down the lateral side of the tibia, but lying behind its posterior margin for most of its length. It expands at its base into the **lateral malleolus**, or outer ankle bone, and unites with the distal tibia to form the mortise of the ankle joint. The head is palpable and the lateral malleolus is superficial, but most of the shaft is buried in muscle.

The fibula is the equivalent of the forearm's radius, but has no equivalent role. The radius is a junior partner at the elbow, with the ulna forming the joint with the humerus, but it expands dramatically as it approaches the wrist and has a dominant part there, rotating across the shaft of the ulna and carrying the hand with it between prone and supine. The long bones of the lower leg contribute to movement only at their joints with the femur and the carpal bones, and the requirements of weight bearing make it inevitable that one large bone must take the whole burden from knee to ankle. The tibia is that bone. The fibula does contribute to the ankle joint and the distal fibula is the focus of much of our interest when the ankle is injured.

Ligaments of the lower leg

The tibia and fibula are linked by ligaments and a fibrous **interosseous membrane**, which binds the bones along their whole length. The membrane is strengthened at its base to form a fibrous joint or **syndesmosis** at the ankle, reinforced by the distal ligaments at front and back.

Bones of the foot (see Fig. 11.1)

The bones of the foot are described in two ways, by zones, the **hindfoot**, the **midfoot** and the **forefoot**, and by groupings of bones (analogous to the groupings of the bones of the wrist and hand). The **tarsal** bones lie in the hindfoot and comprise the **calcaneus** (the heel bone), the **talus** (the bone of the ankle joint) and the five midfoot bones: **cuboid**, **navicular**, and three **cuneiform** bones. In the forefoot, the **metatarsals** correspond to the metacarpals of the hand, five in number, each one shaped like a digit but disguised by the flesh of the foot, and each one supporting one of the five toes. Each toe has phalanges, two for the big toe and three for the others. Unlike the hand, the largest digit of the foot, the big toe, lies on the inner side. It absorbs weight and acts as a push-off point for movement.

The arrangement of the bones may also be seen in terms of medial and lateral groupings. The talus articulates, in a sequence which proceeds distally, with the navicular, the three cuneiforms, metatarsals one to three, and the first three toes. The calcaneus articulates with the cuboid, the fourth and fifth metatarsals, and the fourth and fifth toes.

The calcaneus lies under the ankle bone, the talus, in a vertical line with the tibia and angles down and backwards from that line to form the posterior projection of the heel. At the front and inner surfaces, it articulates with the cuboid. The rounded back of the bone receives the insertion of the Achilles tendon from above. On its plantar surface, it has tubercles for the attachment of various structures including the medial tubercle insertion of the plantar fascia, which can be a site of inflammation (plantar fasciitis).

On the medial side of the calcaneus is a projection called the **sustentaculum tali** (meaning support of the talus), which is the origin of the **plantar calcaneonavicular ligament**, also called the **spring ligament**. This ligament is a part of the soft tissue support of the medial longitudinal arch of the foot. It has already been said that the foot fulfils a double function of bearing weight, which requires contact with the ground, and absorbing the shocks of that contact, which requires a springy arch. The outer foot, metatarsals four and five, aligns itself through the cuboid with the calcaneus at ground level and is the weight-bearing side of the arrangement. The inner part is arranged as a shock absorber: metatarsals one to three meet the midfoot on the 'first floor', not the ground, joining the talus, which sits on top of the calcaneus, through the cuneiforms and the navicular at the apex of an arch which is given tension by the 'bowstring' effect of ligaments and tendons in the plantar foot. The talus has no bony underpinning at its navicular articulation and is subject to downward pressure from the weight of the body, through the leg to the foot. This is resisted by the soft tissue sling of tendons and ligaments, including the spring ligament. If posture collapses at this arch, **pes planus** can develop (the form of flat-foot caused by excessive pronation of the foot). This can cause stresses in the leg, hip and back and painful fixed deformities of the foot. On top of the sustentaculum tali is one of the articular surfaces of the calcaneus for the talus.

The talus articulates with the tibia at its superior **trochlear surface**, which forms the top surface of the **body** of the talus, and the fibular lateral malleolus on its lateral side, to make the ankle joint. It rests upon the calcaneus. The **neck** of the talus passes forwards, downwards and to the inner side of the foot to the point where its **head** articulates with the navicular. Thus, it accepts the weight of the body through the ankle joint and transmits it down and back to the heel through its calcaneal articulations, and forward to the foot through its navicular articulation.

The joints of the ankle and foot (see Fig. 11.1)

The ankle joint, also known (although you may work a lifetime without hearing the phrase) as the **talocrural joint**, is shaped like a mortise and tenon, with the distal tibia and fibula forming the inverted U-shaped ceiling over the body

Box 11.1 Ankle statistics

- Capsular pattern: talocrural joint is plantar flexion more limited than dorsiflexion; subtalar joint is inversion more limited than eversion.
- Joint positions: close-packed position full dorsiflexion; loose-packed position 10° plantar flexion, halfway between inversion and eversion.
- Dorsiflexion 20°; firm endfeel caused by tension in capsule, ligament and tendon.
- Plantar flexion 50°; firm endfeel caused by tension in capsule, ligament and tendon.
- Inversion 30°; firm endfeel caused by lateral capsule and ligaments.
- Eversion 10°; firm endfeel caused by tension in the medial capsule, ligaments and the posterior tibialis muscle.

of the talus. The medial malleolus sits slightly in front of the lateral, so that the foot sits in slight outward rotation. The joint permits the movements of **plantar flexion** (pointing the toes downwards) and **dorsiflexion** (bringing the dorsal foot back towards the shin).

The main parts at which movement of the whole foot occur are the **subtalar joint** (between talus and calcaneus, where inversion and eversion occur) and the **midtarsal** (the combined action of the calcaneocuboid saddle joint and the talonavicular condyloid joint allow inversion and eversion, abduction and adduction, and plantar flexion and dorsiflexion).

Movements of the ankle and foot are usually compound. Dorsiflexion combines with abduction and eversion, and plantar flexion combines with adduction and inversion (Box 11.1).

Collateral ligaments of the ankle (see Fig. 11.1)

The lateral ankle is secured to the foot by three collateral ligaments, the **anterior talofibular ligament**, the central **calcaneofibular ligament** and the **posterior talofibular ligament**. The anterior talofibular ligament is a vital part of ankle joint stability, and also the ligament most likely to be torn by an inversion injury.

The medial ankle's collateral ligaments are divided into several bands, collectively called the **deltoid**, and are stronger and less prone to injury than the lateral group. The relative rarity of medial injury is not only due to the strength of the ligaments: eversion is a smaller movement than inversion because the lateral ankle extends to a lower point than the medial, blocking outward movement of the foot, and it is difficult to stretch the medial ligaments to the point where they will tear. The deltoid is related to the spring ligament and has deep layers formed by the **anterior talotibial** and **posterior talotibial** bands and the more superficial **naviculotibial** ligament. As with the lateral ankle, there is a **calcaneotibial** band.

EXAMINATION

Look

Observe the patient walking: if the ankle joint is swollen there is a tendency to limp on the ball of the foot. If the base of the fifth metatarsal is fractured the patient may walk on the heel, with the forefoot raised, or may pronate the foot to avoid contact between ground and fracture.

We tend to examine the lower leg with the patient seated on a chair rather than on a trolley. A foot rest is very helpful. If you find yourself seated in front of the patient with the injured foot in your hands, be careful to support it well and avoid unconscious pressures from your supporting hand. It tends to be awkward to examine the unsupported foot if you are squatting on the floor.

You may notice that many patients become uneasy when the shoe comes off. They express a dislike for their feet. And, whatever may be true about our hands, many of us are surprisingly unfamiliar with the backs of our feet. This means that a patient's observations abut changes in the ankle or foot after an injury can be misleading. Compare both sides.

Expose both lower legs and feet. Observe posture of the feet and ankles. Are the medial arches of the foot well shaped? Are the heels angulated when seen from behind? Are there hammertoes or bunions? Are there signs of injury, especially bruising and swelling? In the first few hours the swelling caused by an ankle sprain tends to be external, lying like an egg on the lateral malleolus. Later, the whole joint may swell. If the base of the fifth metatarsal is fractured there tends to be a collection of swelling and bruising on the lateral edge of the midfoot and forefoot.

Feel

Seat the patient with the lower leg exposed to the knee and the ankle supported by a foot rest if that is available.

Begin palpation on the lateral side at the head of the fibula. Stress the proximal joint between fibula and tibia and palpate along the line of the shaft of fibula, clothed in muscle until it emerges just above the lateral malleolus. Ankle twists and impacts to the outer leg can fracture the shaft of the fibula, sometimes in combination with the distal tibia. Palpate the anterior, posterior and inferior aspects of the malleolus then feel around the outer body of the malleolus. Tenderness within the malleolus as well

as on its posterior or inferior margin, increases the suspicion of a fracture. Palpate the junction between the distal fibula and tibia at the front and the back. The anterior talofibular ligament is felt on the anterior margin of the lateral malleolus just above the inferior tip. This site is often swollen and tender after an inversion injury, a finding which tends to suggest a sprain rather than a fracture. Just below the lateral ankle is the calcaneus. The anterior margin of the calcaneus is the front margin of he ankle joint on the outer side. On the medial side palpate the shin from the tibial tuberosity down to the medial malleolus: palpate all margins of the projecting ankle. Forward from there is the talonavicular joint, where the ankle gives way to the foot on the medial side. Palpate the calf, the Achilles tendon and the hollows behind the malleoli, pressing into the posterior talus. Ask the patient to relax the toes (to soften the tendons where they cross the front of the ankle) and press into the front dome of the talus. Palpate the foot from the toes proximally: the big toe aligns with the first metatarsal, the medial cuneiform and the navicular; the second and third toes align with their respective metatarsals and the middle and lateral cuneiforms and the navicular. The outer toes align with the fourth and fifth metatarsals and the cuboid. Palpate the projecting hook of the base of the fifth metatarsal, just distal and lateral to the cuboid. Palpate the calcaneus on all aspects including the plantar surface.

If you suspect a stress fracture of the shaft of a metatarsal, axial compression of the bone from its head towards the ankle which causes pain at the symptomatic site is a helpful indicator. You can gain access to the head by lifting its toe and pressing below it, on the plantar side of the metatarsophalangeal joint (MTPJ).

Move

Figures 11.2–11.5 show the main movements of the ankle and their resisted tests. The four resisted tests can be easily performed with the foot and ankle in a neutral position, simply by placing your hand on each of the four surfaces of the foot in turn (dorsum for dorsiflexion, medial for inversion, plantar for plantar flexion, and lateral for eversion) and saying ‘don’t let me move your foot’. The foot will not move at all during the whole process. Passive movements can be carried out from the same starting position.

Ligament stresses at the ankle are various, but a key one is the anterior drawer test for the anterior talofibular ligament (Fig. 11.6). Ask the patient to rest the foot, slightly plantar-flexed, on your volar forearm so that you can grasp the heel at the back in that hand and draw the foot forward. Your other hand should lie against the front of the patient’s shin near the ankle to offer counter traction. Excessive anterior movement of the foot, especially with crepitus, is a positive test.

A suspected Achilles tendon rupture (Fig. 11.7) is examined by asking the patient to kneel on a chair facing over the back with both feet hanging over the front edge of the seat. If the Achilles is ruptured the natural tone of the calf muscle, which causes the foot to hang in slight plantar flexion, will lose its influence and the foot will hang perpendicularly. This makes the back of the heel look flatter. There may also be an obvious step in the distal part of the tendon and bruising. Put your hand around the calf and squeeze gently: this will mimic contraction of the gastrocnemius and should plantar flex the foot if the tendon is intact. Compare the result with the uninjured side. This, the Simmonds test, is a very sensitive examination of Achilles patency. Note that the test is described as positive if the injury is present.

See Box 11.2 for a summary of examination of the foot or lower leg.

X-RAYS

Five different X-ray views may be requested for injuries below the knee. These are:

- The lower leg, or tibia and fibula (anteroposterior [AP] and lateral), for injuries on the shaft of either bone (Fig. 11.8). Some injuries involve both tibia and fibula at different levels and combinations of fracture and sprain are possible. You may require a combination of different views, ankle or knee, with lower leg, to exclude all possible injuries.
- The ankle: AP mortise, a front view with about 20 degrees of internal rotation to show the full outline of the lateral malleolus and the talus sitting within the joint, and a lateral view (Fig. 11.9). A lateral view will show the calcaneus and some departments also include the base of the fifth metatarsal to exclude fracture there without the need for a foot X-ray: note that if the patient is tender further along the shaft of the fifth metatarsal you will need foot X-rays. At the front an ankle X-ray ends at the talonavicular joint and the calcaneocuboid joint. Injuries to the tarsal bones of the midfoot, the cuboid, the navicular and the cuneiforms, require foot X-rays. Below and behind, the heel bone also requires a separate request.
- The heel, also called the calcaneus (see Fig. 11.10 for axial view), calcaneum or the os calcis (a lateral and an axial view taken from behind with a downward angle).
- The foot (an AP and oblique view) which shows the midfoot and the metatarsal bones.
- The toes are requested and X-rayed individually (AP and lateral). It is not usual to X-ray the smaller four toes to diagnose a fracture unless there is a

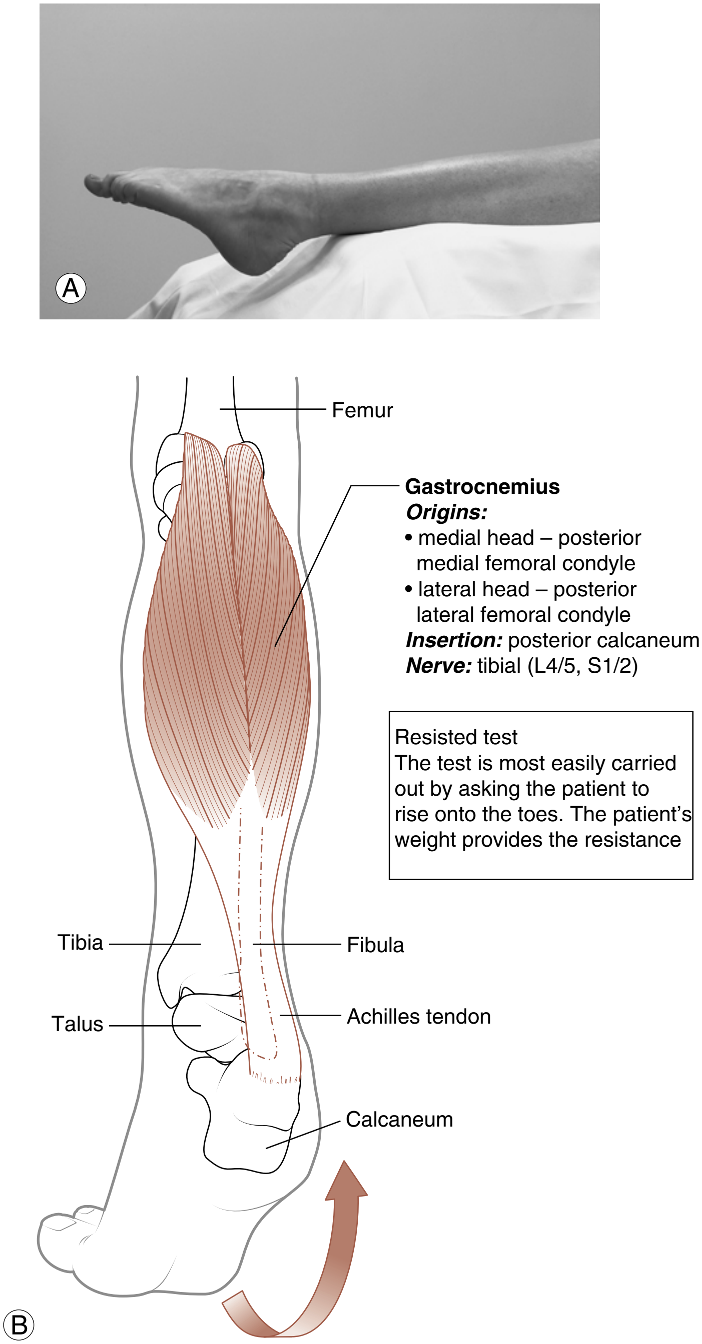

Fig 11.2 A, Active plantar flexion of the ankle. B, Resisted plantar flexion showing muscles of plantar flexion.

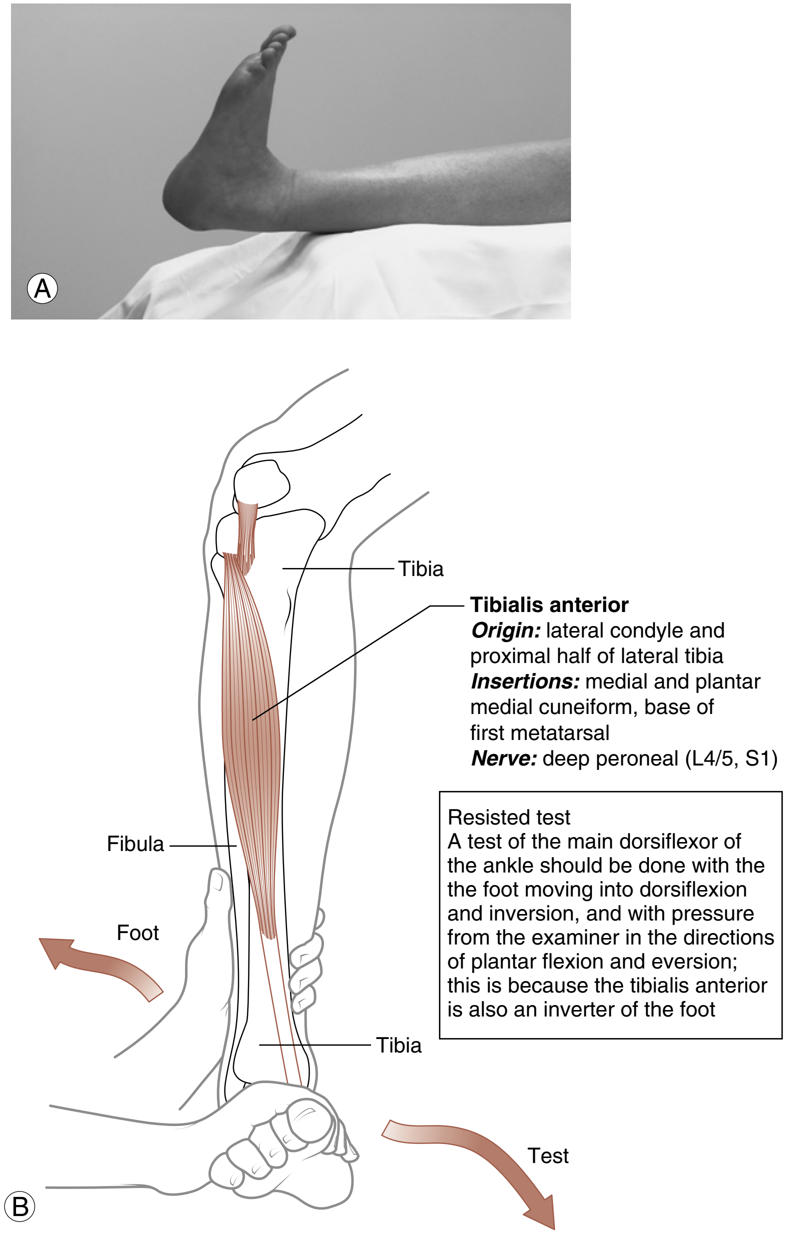

Fig 11.3 A, Active dorsiflexion. B, Resisted dorsiflexion of ankle with muscles of dorsiflexion.

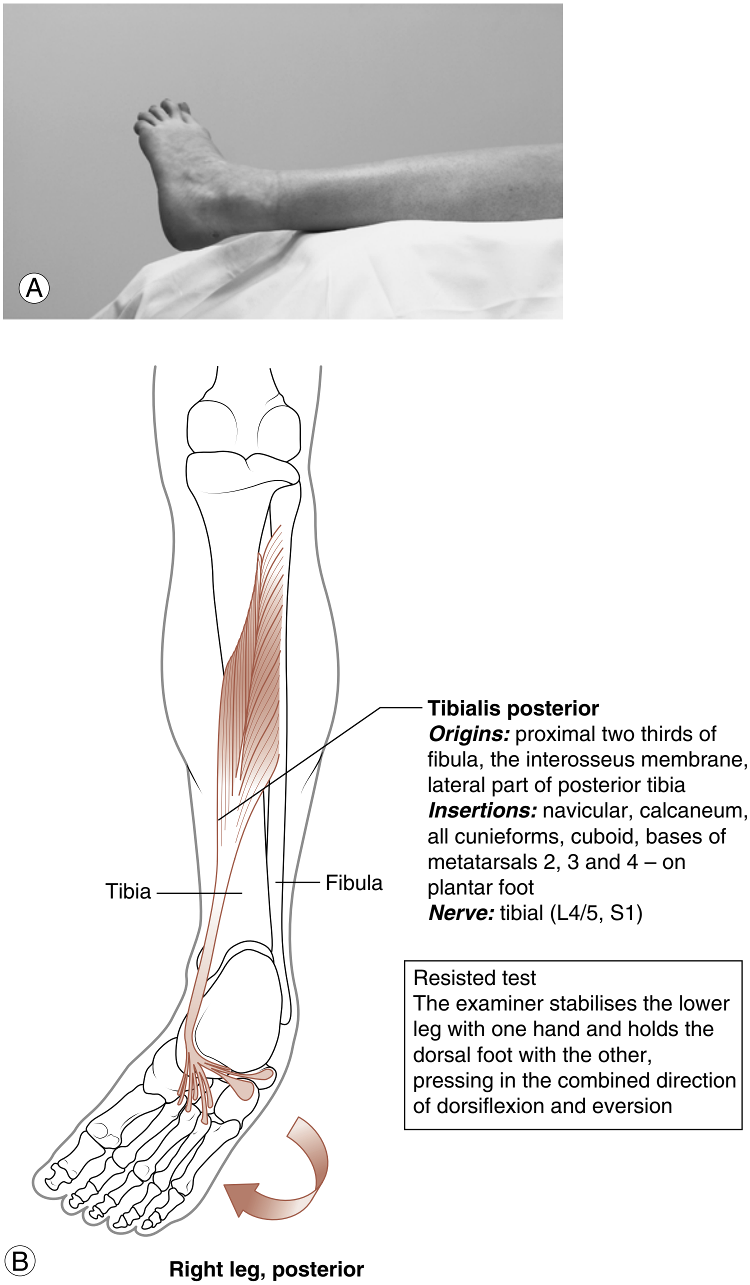

Fig 11.4 A, Active inversion. B, Muscles of inversion.

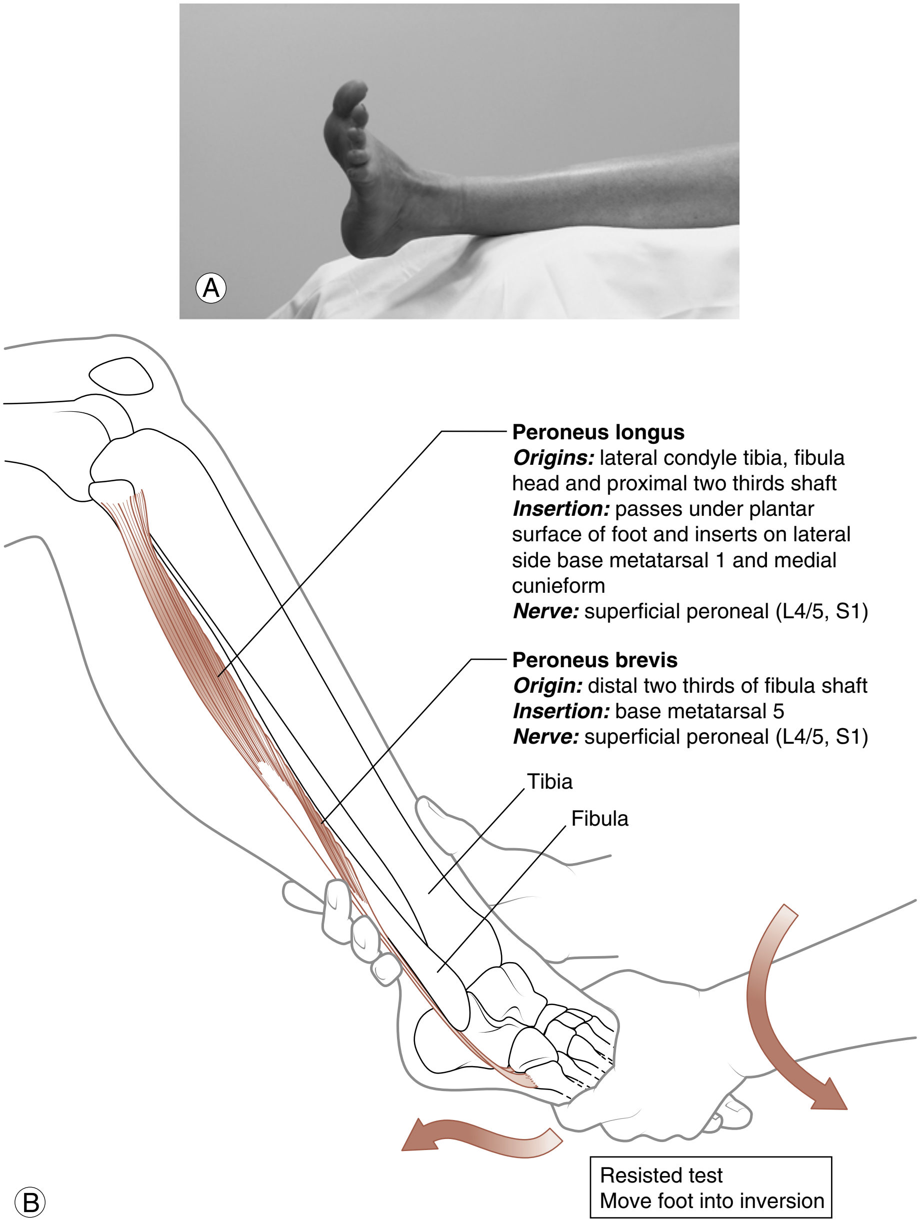

Fig 11.5 A, Active eversion. B, Resisted eversion of foot and ankle with muscles of eversion.

Fig 11.6 The anterior drawer test for the ankle stresses the anterior talofibular ligament: the foot should be in slight plantar flexion for this test.

Fig 11.7 The Simmons test.

concern which may lead to specific treatment, such as displacement or dislocation. This is in accordance with the guidance of the Royal College of Radiologists that images should not be requested if the resulting diagnosis will not alter the patient's management. The big toe is of greater significance to the patient's weight bearing and will be X-rayed when a relevant injury is suspected.

The tibia and fibula

Stress fractures can occur in these bones, particularly at sites where muscle attachments such as the tibialis posterior may be a source of incremental stress. Children of 2 or 3 years old, whose bodies are relatively large and leg bones relatively soft, can suffer a spiral fracture of the tibial shaft from a simple twisting movement, the so-called **toddler's fracture** (Box 11.3). This fracture can be missed if the examiner finds the ankle to be tender and does not request images for the whole lower leg. The mechanism for this injury can be surprisingly slight. X-rays of tibia

Box 11.2 A suggested routine for examination of the foot or lower leg

Observe the patient's gait.

If the history suggests a tear of the Achilles tendon, seat the patient to avoid extending the injury. Ask the patient to expose both legs from below the knees.

Assess distal sensation and circulation.

- LOOK for any bruising, swelling, redness or deformity.
- FEEL all structures below the knee. Key sites include the head of the fibula, the calf, the Achilles tendon, the heel, the malleoli and the base of the 5th metatarsal.
- MOVE the basic combined foot and ankle movement as illustrated. The movements which are tested will depend on the patient's complaint (eg, it is pointless to assess resisted ankle/foot movements with a freshly swollen ankle sprain).

Special test for Achilles tendon tear: the Simmons' (calf squeeze) test. Ask the patient to kneel facing backwards on a chair with both feet hanging over the seat. Look at the injured side: does the foot sit square at the ankle, lacking normal plantar flexion? Squeeze the calf. This should move the foot into plantar flexion. Compare both sides. If the foot fails to move, the test is positive.

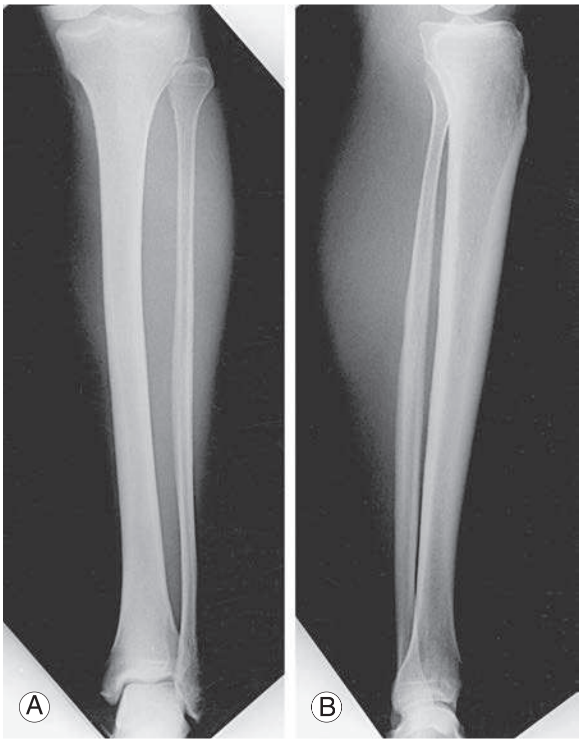

Fig 11.8 Tibia and fibula. (A) Anteroposterior and (B) lateral views. *Source:* From Browner, B., Levine, A., et al., 2008. Skeletal Trauma: Expert Consult: Online and Print, 2-Volume Set, fourth ed. Saunders.

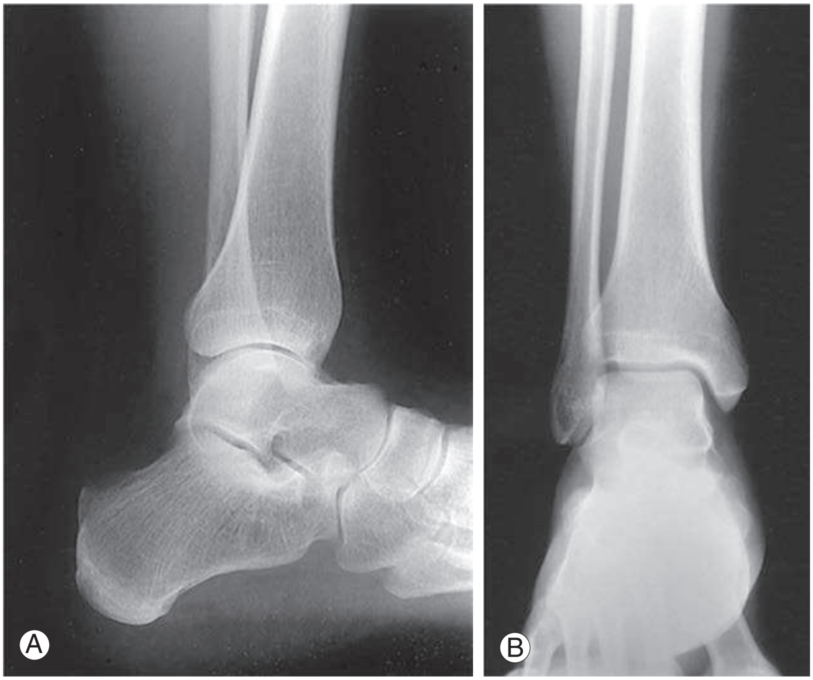

Fig 11.9 Ankle X-rays. (A) Lateral and (B) anteroposterior views.
Source: From Bontrager, K.L., Lampignano, J., 2010. Bontrager's Handbook of Radiographic Positioning and Techniques, seventh ed. Mosby.

Fig 11.10 Axial view of the heel.
Source: From Carver, E., Carrer, B., 2012. Medical Imaging: Techniques, Reflection & Evaluation, second ed. Churchill Livingstone.

Box 11.3 Toddler's fracture

- A child whose walking pattern is still immature (age 1–3).
- No history trauma, but limping for 1–2 days.
- Tender tibia.
- First X-ray often negative, repeat after 10 days may show periosteal reaction or healing fracture.
- Even with no treatment usually does well.

and fibula are often requested to eliminate second fractures when an injury has already been found at the ankle. Injuries of this type follow the 'polo-mint principle' that a circular structure (in this case the upper and lower joints link the two bones into a 'circular' unit) will break in two places, although one of the breaks may be to a ligament. If you suspect that the ankle or the knee is injured, request views of the relevant joint. If you suspect a further injury at another level of the lower leg, request tibia and fibula views as well, but do not omit the joint views. Each view is specific to one part of the limb and may not show another part adequately. If you see talar shift on an ankle X-ray (see Fig. 11.9), but no fracture, request views of the tibia and fibula. Talar shift indicates an unstable

lower leg injury. Many X-rays are requested after a patient suffers a painful impact to the shin. These injuries usually present with a haematoma and tenderness, but relatively few that occur with a minor mechanism are fractures. Late presentations also occur; the haematoma can be slow to disperse and will be painful while it remains. Consider the possibility of infection including osteomyelitis.

The ankle (see Fig. 11.9)

The Ottawa group has produced guidelines for X-rays of the ankle joint. These indicate that for patients between 18 and 60 years of age with an ankle injury, either with tenderness on the posterior margin of either malleolus for a distance of 6 cm down to the inferior tip of the bone, or with ankle pain and inability to walk four steps since injury, an X-ray is indicated. It may also be added that tenderness across the whole exterior body of a malleolus between the anterior and posterior margins increases the suspicion of fracture. Patients who are pregnant or who have broken skin on the site of injury are excluded from the guideline.

The AP mortise view shows the outline of both malleoli and the talus sitting snugly in the space between them. Of equal significance to the bones are the ligaments which are not seen but which hold the joint together, linking the tibia and fibula to each other and to the foot on either side. Inspection of the X-ray should include not only the bones but also the spaces between the bones for widening that will suggest that ligament stability has been lost. There should be a slight overlap between the distal tibia and fibula at the ankle. If there is a gap, the interosseous membrane may be torn. The joint space between the talus and the lower leg bones should be equal on all three sides, lateral, superior and medial, and the joint surfaces of talus and tibia should be smooth. The bones of the lower leg, like those of the forearm, form a single unit, comprising bone and ligament, and they share a tendency, the tendency of circular structures to break in two places, to combined injuries. If you see signs of fracture or ligament rupture on X-ray, always check for a second injury. If the lateral ankle is fractured, look at the mortise for evidence that the talus has moved laterally, so called **talar shift**. Medial fracture (a **bimalleolar fracture**) or ligament rupture must occur to allow this, and it renders the ankle unstable and requiring surgery. Remember also that an ankle X-ray does not capture the whole 'circle' and that you must examine all of the lower leg, and that you may require other X-rays.

On the lateral view the lateral malleolus is seen overlapped on the tibia and passing down below the medial malleolus. Trace its margin with care. Fractures of the distal fibula that are hard to see on the AP view are often revealed on the lateral but you must separate its outline from the contours of the superimposed tibia. Look carefully at the talus: it shares the scaphoid's tendency to lose proximal blood supply if fractured, with a danger of avascular necrosis, and significant fractures can have a subtle appearance on X-ray. Posterior tibial fractures may be seen in combination with bimalleolar fractures, often with backward dislocation of the whole ankle and foot as well as lateral shift. These **trimalleolar fractures** are grossly unstable injuries. Displacement of the ankle must be corrected as quickly as possible even if the patient is going to theatre very soon: the threat to skin and neurovascular structures is high.

There can be a tendency to expect that every painful ankle has been inverted (the patient says 'I twisted my ankle' and you write down 'inversion' without an intervening question). If a fixed foot is rotated within the ankle joint the talus, which is wider along its side than its front, can burst the syndesmosis of the ankle. An eversion injury which causes a large lateral swelling is much more likely to be a fracture than anything else. Take care to clarify the mechanism of injury with every patient.

The heel

The lateral ankle view gives a beguilingly complete lateral view of the heel. Do not be tempted to settle for an ankle view to assess a possible injury to the calcaneus. Fractures through the heel bone can be subtle on X-ray to an extent which becomes astonishing when the severity and complexity of the injury are revealed, perhaps on a computed tomography (CT) scan: take advantage of the second image which a request for heel views will bring (see Fig. 11.10). Use the trabeculae, the web of cancellous bone which patterns X-rays of bones, to detect any interruption, overlap or change of direction which would indicate a fracture. Be suspicious of any lucency or sclerotic area. View the cortical margin of the axial view with great care. The exposure quality of axial views can vary greatly within one X-ray because the bone thickness is so variable but the modern digital image can be adjusted to bring out different exposure levels within the same image.

Large fractures to the heel bone, the calcaneus, are usually caused by jumping from a height. The joint between the talus and the calcaneus, the subtalar joint, may be crushed. On a lateral X-ray assess this joint by measuring Bohler's angle. Draw two straight lines, one from the top front corner of the calcaneus, and one from the top back corner so that they cross at the highest point of the calcaneus in the subtalar area. The junction of these two lines creates four angles: Bohler's angle is the posterior one, and it should not be less than 30 degrees. It is axiomatic that a jumping injury which fractures the heel transmits force which can also fracture the spine and you will consider that and rule it out: treat any clinical signs of spinal injury with a high degree of suspicion.

Smaller calcaneal fractures occur with ankle injuries at the joint between calcaneus and cuboid. These injuries are not always picked up on calcaneal views. Request foot X-rays if the patient is bruised and tender at the calcaneocuboid area.

The foot (Fig. 11.11)

Foot X-rays are requested for injuries in the mid and forefoot, from the posterior margin of the cuboid and navicular to the MTPJs. Ottawa guidelines for requesting X-rays of the foot are that pain in the midfoot with tenderness of the base of the fifth metatarsal or navicular merit X-ray. The exclusions and weight-bearing criteria are the same as for the ankle. These guidelines relate to ankle injuries which may also cause fractures in the foot. Other presentations involving the foot alone must be judged on their clinical merits. Be careful with complex mechanisms. A patient who 'twists the ankle' by stepping into a rabbit-hole on a hill can apply rotational forces along the whole foot as well as inverting the ankle and fractures can occur which are not mentioned in the Ottawa guidelines.

However, it remains true that the commonest mechanism of injury in the ankle and foot is inversion, and this may, in addition to fractures and sprains at the ankle itself, cause an avulsion fracture of the base of the fifth metatarsal. The peroneus brevis muscle (see Fig. 11.5), which contributes to eversion of the ankle, and which is attached to the little process at the base of the metatarsal, can avulse its insertion during inversion. It is usually possible on examination to distinguish between patients whose main complaint is in the ankle or the foot, and you should not routinely X-ray both. Note that children have an apophysis at the base of the fifth metatarsal which lies parallel to the bone and which should not be mistaken for a fracture, which tends to be transverse.

Fig 11.11 Foot X-rays. (A) Anteroposterior and (B) oblique views. *Source:* From Magee, et al., 2007. Scientific Foundations and Principles of Practice in Musculoskeletal Rehabilitation, Saunders.

The tarsal bones are difficult to see separately on X-ray, but the AP view should show medial alignment of the second metatarsal and the intermediate cuneiform and the oblique view should show the same for the third metatarsal and the lateral cuneiform. Trauma at the tarsal–metatarsal joints can produce a variety of dislocations and fractures, called Lisfranc injuries. These are severe injuries with correspondingly severe presentations, with gross swelling, pain and inability to walk, but X-rays can be misleadingly subtle: a dislocation with lateral shift of metatarsals two to five requires careful scrutiny of the alignment of the metatarsals with the tarsals, looking closely at the alignment of the second and third metatarsals with their cuneiforms, to pick up the change.

Metatarsal fractures can be the result of direct trauma, but stress fractures also occur. These are most common in the second and third metatarsals. The patient should have a history of frequent activity, walking, standing a lot or running. Tenderness on the shaft of the bone, especially if present on dorsal and plantar aspects and combined with pain on axial compression of the head of the metatarsal, are clinically suggestive features of the examination. X-rays may show a fracture or signs of injury such as a periosteal reaction or callus, but stress fractures may be present with no change on the X-ray and your clinical impression will be the deciding factor in your management.

The toes

Take care if a patient presents with a swollen toe after an injury. We do not X-ray any toe except the big one for most injuries, but dislocation in a small digit can be well concealed in a bruised swelling. Examine each joint with care before deciding not to X-ray. Another pattern of injury to treat warily is the barefoot stub of the little toe. It is common for the little toe to be abducted if it hits something, and this inflicts a mobile diagonal fracture of the proximal phalanx. If this injury is not well positioned during healing (buddy-strapping is all that is needed, but it must be used consistently and well) the toe can heal in an angulated position which will cause great trouble with footwear. Hyperextension of a toe with a ragged wound on the plantar crease of the MTPJ may be an open dislocation with or without fracture, an injury which requires X-ray, exploration, and may require orthopaedic referral. Therefore, in deciding not to X-ray, satisfy yourself that dislocation, angulation and open injury are not part of the clinical picture.

INJURIES

Lower leg fractures

See also above, in the section on X-rays.

Tibia

The tibia is a large weight-bearing bone and, in general, fractures are significant in terms of pain, shock, disability, combined injuries and risk of complications: many patients will require trauma centre management. Four types of injury to the tibia do present at minor injury units.

- Fractures of the medial malleolus. Medial ankle injuries in isolation are much less common than lateral injuries. They can also be part of a larger presentation where the whole ankle is unstable.
- Stress fractures to the shaft of the bone caused by running, a phenomenon which can relate to 'shin-splint' pain in sporty adolescents, and be a later consequence of muscle origin pain from tibialis posterior.
- The so-called 'toddler's fracture', which occurs with a relatively small mechanism when a child of 2–3 years has relatively large trunk and small legs (see Box 11.3). A twisting movement can cause a linear spiral fracture through the shaft of the soft tibia. This injury will heal with conservative care.
- In adolescents, the growth plate of the distal tibia closes from the centre medially, leaving a small area still open at the lateral side, at the distal tibiofibular joint. This represents a weak point which can suffer a Salter–Harris III injury, known as a Tillaux fracture, from an ankle twist. This injury looks small, and can be missed if there is any rotation on the ankle X-ray, but it requires orthopaedic management. A larger injury can result from the same growth dynamic and mechanism, a triplane fracture. This injury involves metaphysis, growth plate and epiphysis, and is a major orthopaedic injury.

Major tibial fractures usually happen in one of three ways:

- by a twist during an activity like skiing
- by a fall from a height onto the feet (a mechanism which may also produce bimalleolar or trimalleolar fracture and dislocation at the ankle, calcaneal fracture and injury to the spine)
- by a direct blow, especially to the superficial shin, often during a severe event such as a road traffic accident.

Open fractures occur at the shin, and severe blood loss is likely. Damage to nerves and blood vessels is possible. There is a risk of complication, including acute compartment syndrome, which is assessed not only on the severity of the fracture but also the soft tissue damage and contamination of the wound. Assess perfusion and innervation distal to the injury. Control bleeding and dress any wound. Give pain relief. Obtain intravenous access as soon as that is practicable. The priority is a prompt transfer to orthopaedic surgeons.

Fibula

The fibula may suffer a combined fracture with the tibia (although the injury may be at a different level of the bone). The fibula does not bear weight at the knee. An isolated fibular fracture is often inflicted by a direct force, such as a kick at football, or by an indirect twisting force at the ankle. It may not stop the patient from walking and he or she may not present for treatment right away. An undisplaced and uncomplicated injury may require no active treatment in any case. However, a fracture to the fibula may affect the tibiofibular syndesmosis and ligaments (see Fig. 11.1), and the ankle joint requires careful assessment. Conversely, an ankle injury, especially in cases where there is a twisting force applied to the foot, may injure the fibula anywhere along its shaft or at the proximal tibiofibular articulation. Examination of the ankle must include the whole fibula. Fractures at the distal end of the fibula, caused by injury at the ankle, may destabilise the ankle joint. Stress fractures may happen in the fibula in the young and sporting or in the elderly and osteoporotic.

Ankle injuries

Ankle injuries are discussed with fractures because that is the first diagnosis which you will exclude: however, nine out of ten of these injuries are sprains. The inversion injury of the ankle, 'going over on it', is the commonest single injury seen in MIUs (although hands are the commonest site for injuries). The patient feels the ankle forced into inversion. Sometimes the mechanism is violent; sometimes it is trivial. The injury may be aggravated by extra force, if the patient is running, jumping, on uneven ground, falling from a height or if the weight of another person is added. Patients who have had previous ankle injuries may be predisposed to further injury (the so-called 'weak' ankle which rarely has anything to do with loss of muscle power but is more likely to be caused by a defect in proprioception).

There is sickening pain. The patient usually has to sit or lie down and may feel faint and dizzy. There may be a sudden, immediate swelling, sometimes an 'egg' over the

lateral malleolus, or swelling and bruising over a matter of hours. If swelling is large, the ankle may move into its loose-packed position. The patient may feel pain at the lateral ankle, over the lateral foot, tingling in the foot and shooting pains along the dorsal foot to the shin.

If the injury is a displaced fracture there may be deformity consistent with dislocation or widening of the ankle joint (see bi- and trimalleolar fractures above in the X-ray section), and the patient may need urgent orthopaedic treatment to reduce and stabilise the injury. The injury should be splinted, with a box splint if that is possible, constantly reassessing the distal innervation and circulation and inspecting the skin. The patient should be transferred as soon as possible.

Walking is always affected, and the severity of the injury may be partly assessed by the history of the patient's ability to walk from the time of injury until seen at the clinic. The common result of the inversion injury is to overstretch the soft tissues on the lateral side of the ankle – skin, tendons, joint capsule and ligaments – and to cause a sprain. The same mechanism may cause an avulsion fracture from the base of the lateral malleolus. The anterior talofibular ligament is the most likely structure to suffer a grade 3 injury, and the anterior drawer test has been described in the examination section (see Fig. 11.6).

Ultimately, although we use proxy measures such as weight bearing and swelling to assess the severity of an ankle sprain because full examination can be difficult at first, the proportion of the ligament injury and the loss of stability decides the severity of the injury.

An apparently severe, fresh sprain should be immobilised in a cast or equivalent splint for an initial period and reviewed according to your local arrangements for a full assessment.

If the pattern of injury has not been typical (if, for instance, there has been a rotation or eversion injury), there may be injury to ligaments other than those at the lateral ankle, and any patient who has a severe-looking injury should have further assessment in accordance with your local follow-up arrangements. There may be a need for immobilisation, soft tissue scanning and orthopaedic review.

Pain may be considerable in the first 1 to 2 days. Recommend analgesia (ibuprofen is often advocated if the patient can tolerate it), crutches may be required and the patient should be warned that it is common to have pain for 6 weeks or longer.

If the patient is discharged in the expectation that walking will improve rapidly, give advice to return in a week if that does not happen.

The heel is unlikely to suffer fracture from a slight injury although violent force can sometimes be a matter of angle and speed rather than height: but fracture is usually caused by falling onto the feet from a considerable height. The force which fractures the heel is sufficient to injure the spine and you will assess the patient from the neck down.

The foot

A fracture most often seen in women of middle age is at the insertion of the peroneus brevis muscle into the base of the fifth metatarsal. Inversion stretches or provokes a contraction in the muscle and causes an avulsion injury. This fracture, if it is uncomplicated, is often treated by rest and symptomatic support, crutches and analgesia. If the foot is very violently inverted, the tip of the medial malleolus may also be crushed. If the fracture passes into the cuboid-metatarsal joint it may have a much greater impact on walking and the patient may need a cast or orthopaedic boot.

Crush injuries to the foot from a heavy weight are often severely painful, and fracture is possible: X-ray the foot. Make sure that you do not miss a Lisfranc injury. Consider acute compartment syndrome: the loss of passive toe movements is a worrying sign. If in doubt, the patient should be referred for orthopaedic review. A patient who is discharged should take painkillers and use ice and elevation to reduce swelling. It is likely that the patient will need crutches. Advise the patient to return if the pain is worse or if circulation or sensation to the toes is reduced.

Stubbed toes are very painful. Patients present with bruised swollen toes and pain on walking. They ask for an X-ray. If there is no obvious deformity of the toe, it is unlikely that X-ray will influence management. The toes require buddy-strapping, ice and elevation; the patient should use pain killers. The pain will usually be more manageable in a few days when swelling reduces, but will persist at a lower level for up to 6 weeks if a fracture has occurred. X-rays of the four smaller toes are required if dislocation or a mobile, displaced fracture are suspected. X-ray of the big toe is requested for a possible fracture.

Lower leg pain

'Shin splints'

'Shin splints' usually refers to teenage athletes who are complaining of pain somewhere in the front and medial side, but not the back, of the lower leg, below the knee and above the ankle. There is a history of commitment to a sport that will certainly make an overuse problem plausible but there is no story of a violent injury. 'Shin splints' is too vague a term to be of use to you: this is not a single condition and the treatments of its various causes are different. There are four commonly recognised conditions which cause shin pain:

- **Chronic** (or **exertional**) **compartment syndrome** occurs when a muscle which is active

and engorged with blood becomes too large for its wrapping of fascia and suffers painful compression which worsens as activity is increased and diminishes when the patient rests. The incompatibility of the muscle with its sheath may occur because of shrinkage of the fascia, perhaps caused by scarring. This condition is distinguished by the direct relationship between exertion and pain: this, however, makes it difficult to demonstrate the problem on examination. Physiotherapy may be helpful but a referral to a sports or orthopaedic specialist may also be necessary.

- **Medial tibial periostitis** (also called **medial tibial stress syndrome**) occurs at the angle between the superficial, medial aspect of the shin and its posterior surface. Muscle and fascia insertions into the bone which are stressed by overuse become inflamed. The condition is distinguished by marked tenderness on the anterior to posterior angle of the tibia, usually a few centimetres above the ankle. Initial management is rest and ice with physiotherapy if it is more than a mild problem.
- **Tenosynovitis of the tibialis anterior muscle** is experienced at the front of the lower shin in the tendon of the muscle which crosses from the lateral knee to the medial foot. It is often accompanied by swelling and crepitus in the shin when the ankle is rotated. A severe case is difficult to manage because active dorsiflexion of the ankle hurts and letting the foot hang in plantar flexion stretches the muscle and is also painful: this means that the patient will even have trouble managing on crutches. Ankle strapping which supports the foot without contracting or stretching tibialis anterior can be helpful. Rest is an absolute requirement to settle the problem, with a graduated return to activity when pain is settled. If pain returns then it may be necessary to review issues around the patient's sporting activities, including training and equipment, and to assess the patient's physical attributes, with particular interest in the feet. The tibialis anterior is also a site where both acute and chronic compartment syndrome can occur.
- **Tibial stress fractures** can occur at different levels of the bone but a particularly severe and surprising injury can occur in the proximal tibia, just distal to the tuberosity, which is thought to be a final result of prolonged stress at the attachment point of the tibialis posterior muscle, probably caused by a problem with the posture of the foot. The fracture can occur explosively although with little or no injury, and on X-ray it is far from the usual hairline or subtle appearance that we usually associate with stress fractures.

Calf pain and injury

A gastrocnemius tear is a common sports injury especially but not exclusively in patients who are middle-aged and returning to sport after a long break, or who are at an event like a dance where uninhibited and unfamiliar movements catch the muscle by surprise; it usually occurs at the medial head at its widest point, or at the Achilles musculotendinous junction. The patient will describe a sudden 'blow' to the calf while lunging forward. Stretching of the muscle will hurt and the patient will walk on the ball of the foot with the knee bent, the equinus gait. There will be tenderness at the tear, and bruising, swelling and a palpable gap in the tissue are possible. Passive dorsiflexion of the foot will hurt. The patient should rest and use ice to allow bleeding to settle. It is preferable with all but the smallest injuries to refer to a physiotherapist. Advise the use of orthopaedic felt to raise the heel to avoid stress on the tear. The patient may need crutches.

Other causes of calf pain include acute and chronic compartment syndromes. The risk of a deep vein thrombosis must be assessed in any patient who presents with calf pain with no history of injury. The absence of the classic signs, redness, heat and swelling, do not exclude the possibility. A ruptured Baker's cyst may mimic the appearance of deep vein thrombosis; this cyst is a herniated sac of synovial fluid in the popliteal area of the knee, which may open and drain into the calf. Ischaemic artery disease may cause pain in the lower leg, but it is unlikely that the undiagnosed condition would present in a minor injury clinic. Infection, superficial or deep, in the lower leg should be excluded.

The Achilles tendon

The Achilles tendon is prone to two injuries: overuse pain and rupture. The first may predispose to the second.

Achilles tendonosis is common among sportsmen, especially such groups as long-distance runners. Pain is felt at the back of the ankle, just above the heel. There may be swelling, tenderness, reduced ankle movement and difficulty walking. The pain will be felt on movement: it will also be present on rising in the morning, and will initially settle with gentle movement but return when activity increases. This type of pain was formerly attributed to inflammation, but is now thought to be associated with hypertrophic changes in the tendon and the accompanying development of new nerve and vascular structures, and treatments such as the injection of vascular sclerosing agents into the new vessels, such as are used for varicose veins, have shown some success. In the early stage of management the emphasis would

move from anti-inflammatory agents to simple analgesia and rest. Disability can be severe and the problem can be chronic. Crutches and ankle strapping may be required.

Achilles tendon rupture (see Fig. 11.7) occurs by a similar mechanism of injury to that for a calf muscle tear, but the presentation and clinical appearance are different. There is an even greater likelihood that the patient will be a middle-aged person (there is often a degenerative aspect to the injury and young patients are uncommon) taking on an unfamiliar level of activity which includes jumping or lunging. The rupture may be partial or complete.

The patient feels a sudden 'crack' over the tendon, usually after a sudden lunge forward on the affected foot and will probably collapse. The patient often has, in common with a gastrocnemius injury, a strong sense that the injury has originated from an external impact (sometimes called the 'sniper's bullet effect'), and, if this conviction persists, it may appear in the history and mislead you. Even if the patient feels that walking is possible, the sense of having poor control of the foot makes patients wary of trying. The Simmons test for Achilles rupture is described in the examination section.

This injury needs orthopaedic treatment. There are both surgical and conservative treatment options. Recovery tends to be very slow, a matter of months. In either case you will usually begin treatment by applying an 'equinus' cast with the foot in plantar flexion to bring the torn ends of the tendon together. The patient will require crutches.

Some foot problems:

- **Plantar fasciitis** often occurs in later middle age. It can be a crippling and stubborn problem. Heel pain is felt on rising and on weight bearing, with no history of injury. There will be tenderness at the medial tubercle. An X-ray may show a bony spur at that site, although the relationship between the spur and the pain is not clear enough to justify imaging for this presentation. The painful spot is the insertion point for the plantar aponeurosis. This passes forward along the sole of the foot to the connective tissues at the toes. The pain may be difficult to treat. There is an association between plantar fasciitis and shortness of the gastrocnemius muscle, and physiotherapy advice may be useful. Podiatry assessment may also be beneficial. Heel pads to relieve pressure, ultrasound and hydrocortisone injections may all be tried.
- Tendinitis is common in the ankle and foot because of too much walking or running. It often occurs in the extensor tendons of the ankle and foot at the anterior ankle. Pain follows the inflammatory pattern. There may be crepitus in the tendon of tibialis anterior, on the shin (see 'shin splints' above). Immediate treatment is rest and ibuprofen if the patient can tolerate it. Gentle activity should be resumed when the symptoms have settled.
- Children may suffer foot pain for a variety of growth-related reasons. The risk of infection and systemic disease must always be considered. Traction apophysitis, the pulling of a tendon on its bony attachment, causing widening and pain in the growth plate at the site, occurs at the back of the calcaneus where it is joined by the Achilles tendon: there will be tenderness, pain on exertion, and sometimes visible enlargement of the heel. This is called Sever's disease. Advise the patient to accommodate the problem by reducing activity when it is symptomatic. It settles when growth is complete. Avascular necrosis can afflict growing bones. Kohler's disease affects the navicular and Freiberg's disease the head of a metatarsal, often the second. Consider these possibilities when children present with foot pain.
- Paronychia may occur around the nails of the toes, in a similar manner to those of the hand.
- It is common to see a patient with sudden pain, redness and swelling in the big toe at the MTPJ, with no history of injury. Septic arthritis and cellulitis must be excluded before the patient can be safely discharged to the care of his or her general practitioner. If there is any suggestion of infection, local or systemic, manage this by the agreed pathway in your local area. Osteoarthritis and gout are common causes for acute non-infective episodes of this kind.

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Part 3

Midline injuries

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Chapter 12

Minor head injuries

CONTENTS

HEAD INJURIES AND INJURIES TO THE MIDLINE

We can meet a stranger and chat for a few minutes and say afterwards that we 'know' that person. We do not mean much by that: we make a distinction between people that we have met in the flesh and everyone else and we call it 'knowing'. When we meet someone who has taken a knock to the head, we follow a process that takes us from our initial greeting to the point where we send the patient home; it would be reassuring if we could say that we know something at the time of the patient's going that we did not know when he or she arrived, but if we cannot get inside a stranger's skin at a first meeting still less can we be certain that an injured man is not quietly bleeding away inside his head. Clinical activity is driven by the paradox that something can be under our hands but out of reach.

This section of the book opens with minor head injuries, the first of a sequence of chapters on injuries to the midline of the body. You are in different territory here, with different objectives and different methods of attaining your objectives. You will find that it is harder to answer simple questions, sometimes because you are not interested in the same issues as the patient and sometimes because your examination will not give you a clear answer. You will not reach a diagnosis as often as with injuries to the limbs. You will be more interested in ruling out dangerous things than in discovering what smaller thing is actually wrong. Even in the attempt to rule things out you will not reach certainty and it will be important for you to accept that and to learn how to work with it, but also to tolerate only as much uncertainty as current practice allows.

The diagnosis of limb injuries is based on our ability to test structures which are hidden below the skin but which we can isolate and mobilise. The underlying principle which applies to the limb but not to the midline of the body is that, with occasional exceptions, significant injuries are significant because they have disabled an important structure and that we can test that structure and make the disability show itself. In the midline of the body where vital organs are hidden away in capsules and bony boxes, examination is less direct and the organ itself may not be the structure which is injured: a possible source of harm is insidious bleeding which can either compress the host organ inside its receptacle or announce itself by a sudden haemorrhage. Until the bleed reaches a critical point the patient may be well and there may be little to find on clinical examination. This is not a problem in many cases: if a patient suffers a violent injury and is severely compromised then all avenues will be fully explored and imaging, and perhaps other measures such as surgical exploration, will compensate for our clinical limitations. And if the injury is minor, a mere knock, the consequences are likely to be equally minor. However, it occasionally happens that a trivial event, or an event which appears to be trivial, causes a life-threatening injury, an injury which begins so quietly that we are in danger of missing it. There is a mismatch between the way that the injury presents and its consequences and there can also be a mismatch between the patient's need and the resources of the service he or she has chosen to consult.

This means that minor injuries to the midline of the body are managed in a deliberately disproportionate way. The patient comes to a minor injury unit (MIU) with a story of a minor injury and we respond by looking for signs of a major injury.

The commonest, but not the only, major event that we try to exclude is haemorrhage. The commonest, but not the only, question that we set ourselves in such cases is not 'is the patient bleeding?' but 'does the patient require imaging?' We do not need to be certain that there is a bleed: often we cannot be certain. We merely have to cross a threshold that is set low because of the risk that is involved and decide that it is more likely for this patient than for another. The fact that bleeding is often the main question means that X-ray, a key resource in an MIU, is not usually the form of imaging that we are considering: this means that we will have to refer the patient to a doctor. When the patient has suffered a head injury we usually consider referral for a computed tomography (CT) scan. Our main reason for considering an alternative would be the lack of an available scanner.

We rely on another resource to support our clinical assessment of patients with head injuries (and of other injuries to the midline), national or international guidelines. Guidelines allow you to measure your clinical findings against evidence-based recommendations, the sum of our collective knowledge, for those results. They reduce uncertainty and allow you to base decisions which would otherwise be down to 'clinical judgement' or 'gut feeling' on something more authoritative. Referral and consultation can be harmonious because you have a shared framework with your colleagues. You also have a source of support if you are asked to account for your care. For patients with injuries to the head, once again, the guidelines are directing you towards those who require a CT scan to exclude a bleed within the cranium. In the United Kingdom the National Institute for Health and Care Excellence (NICE) issues head injury guidelines for England and Wales (2014) and the Scottish Intercollegiate Guideline Network (SIGN) does the same in Scotland (2009 with later amendments).

Certain aspects of a presentation will increase our concern about an injury to the midline:

- A severe mechanism of injury. The definition and the details of a severe mechanism will vary from one part of the body to another. The NICE definitions of a severe mechanism for adults and for children with head injuries are given below.
- Patients at either end of the lifespan tend to be more vulnerable, sometimes unable to give a history, with a weaker physical frame than a mature adult, and also more difficult to assess in terms of guidelines.
- Patients who are not fully alert or have a cognitive problem which makes a history difficult and an examination unreliable.
- Patients with medical problems or who are taking medicines which make an injury more dangerous and who also raise the possibility that an episode of illness is masquerading as an injury.

We cannot scan every head-injured patient who presents to an emergency department (ED) or MIU without bringing our imaging services to a halt and without an exponential increase in the population's exposure to radiation: but we do not infallibly detect every case that needs referral and we also refer patients who are found to be well. This process involves a life-threatening hazard for the patient and a medico-legal risk for you, all the while searching for significant cases among a large majority whose injuries are as mild as they seem. You have the twin problems of distinguishing a quiet condition from a non-existent one and of maintaining your alertness when almost every case is genuinely minor.

ANATOMY

The brain and spinal cord are, together, the **central nervous system**. The neural tissues of the brain are delicate and damage to them is irreversible.

The **cranial** part of the skull (Fig. 12.1) is a bony box which holds and protects the brain. The bones which contribute to this structure are the **frontal**, **parietal**, **temporal** and **occipital**.

The box is not a sealed container. It has many openings to permit the passage of blood vessels and nerves and a large passage in its occipital floor, the **foramen magnum**, through which the **brainstem** gives way to the spinal cord. It then passes into the vertebral canal of the spine. However, neither these openings nor the joints between the various bones of the cranium provides sufficient leeway to absorb the extra pressure which occurs inside the cranium if there is bleeding caused by injury or if the brain should swell (**cerebral oedema**). The effects of **raised intracranial pressure** are transmitted to the soft brain itself, and its rigid protective environment becomes a liability. Violent impacts or sudden movements of the head can throw the brain against the hard edges and surfaces of the cranial bones, resulting in contusion and damage to the brain.

The brain has other forms of protection. It is covered by three layers of protective fibrous material, the **meninges**. The innermost layer is the **pia mater** (meaning tender mother). This is a fine, richly vascular tissue which clothes the outline of the brain. The middle layer is the **arachnoid** (meaning cobweb), a layer of fine tissue which is separated from the pia mater by the **subarachnoid space** and joined to it by web-like attachments, which give the arachnoid its name. The subarachnoid space contains **cerebrospinal fluid** (CSF) and blood vessels. The outer layer is the **dura mater** (meaning hard mother), a tough tissue which covers brain and forms the **dural sheath** around the spinal cord. Bleeding which occurs in the space between the skull and the dura mater (**epidural** haemorrhage) is usually caused by trauma to the temporal bone, causing fracture and

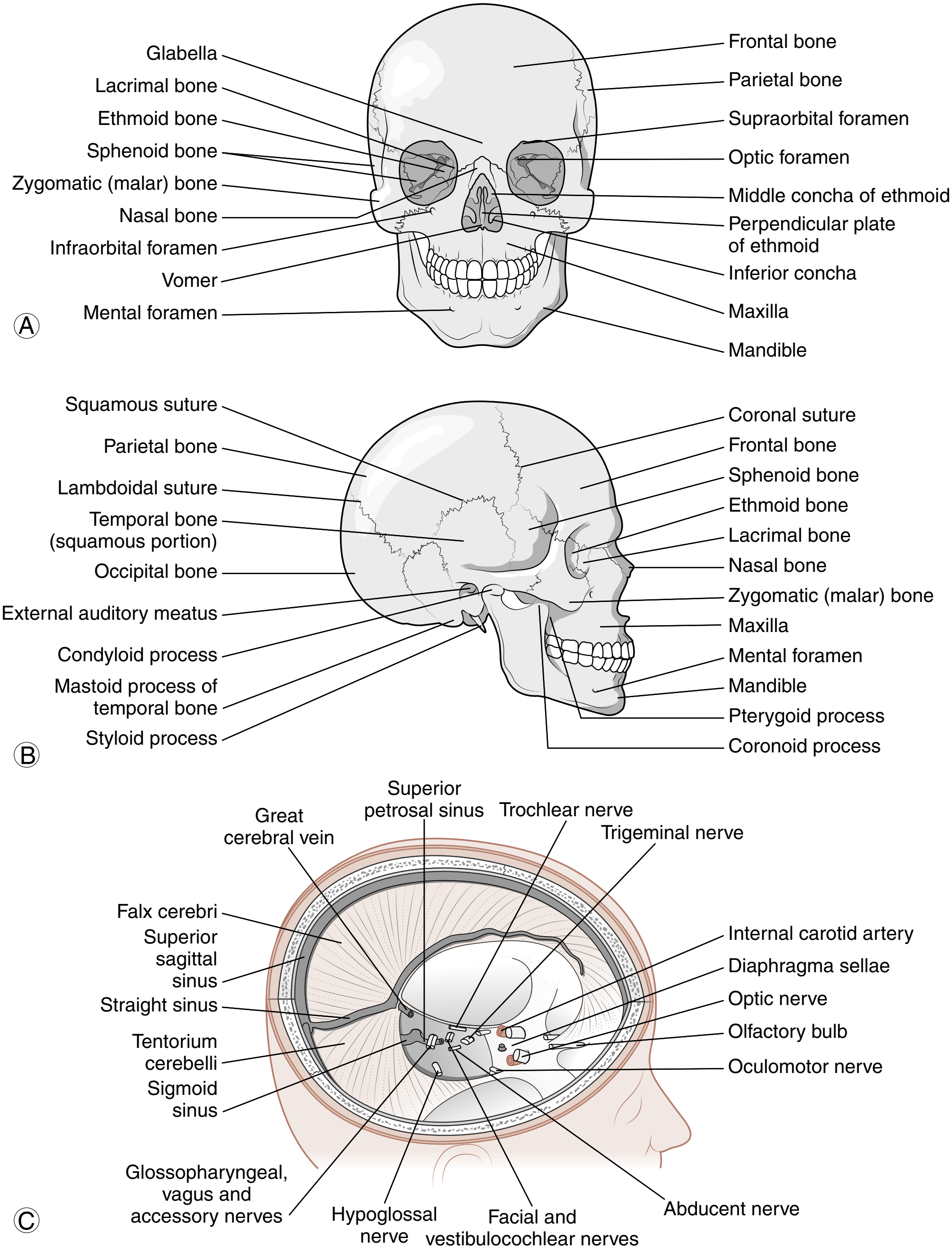


Fig 12.1 The cranial part of the skull. A, Anterior view of the skull. B, View from the right side. C, The dura mater exposed by removal of part of the right half of the skull and brain.

bleeding from the meningeal artery. The patient deteriorates very quickly and needs immediate surgery to remove the haematoma. A **subdural** haemorrhage is venous and the patient may not deteriorate so quickly.

The brain floats in, and is protected and nourished by, CSF, a liquid formed from, and similar to, plasma. The spinal cord is also surrounded by this liquid. The level of CSF in the brain is delicately regulated to avoid excess pressure.

Our state of consciousness, of awareness in the world, resides in the brain and can be extinguished there. The brain is the centre where all those functions of our inner life that we might call thought and feeling arise. The brain regulates the body, its internal environment and its responses to external changes. It receives the signals from the five senses and translates them into the experiences which we call sight, smell, sound, taste and sensation. It sends out the signals which enable us to act in the world. The vast array of cerebral functions is relegated to specialised zones in the brain. The part of the brain which lies at its base, the brainstem, is of particular concern in the head-injured person who is suffering from the effects of rising intracranial pressure. This area regulates vital functions such as breathing, heartbeat and consciousness itself. Increased pressure on the brain will tend to drive the brainstem into the foramen magnum, the access point to the spinal canal, a fatal process called **coning**.

MINOR HEAD INJURIES AND IMAGING

Many patients attend MIUs with injuries to the head or face, which might be called 'head injuries' in the anatomical sense but are more appropriately categorised as lacerations to scalp, or eyebrow or wherever.

A common tale is of a clash of heads on the rugby field, where the patient does not know that he is injured until some blood runs down into his eye, or of a workman who stands up below a shelf with a sharp corner and cuts the top of the head. The injured person has an instant of sharp, superficial pain and no other symptom except the bleeding which brings the patient for treatment.

Patients with problems of this kind must be assessed neurologically as well as having the superficial injury treated and they will be sent home in the care of a concerned relative with a sheet of head injury instructions and advice on the care of staples or sutures.

There is clearly a difference between that and the kind of event where a patient is brought to your unit, pale and shaken, upset, unable to remember his injury, complaining of a headache and vomiting repeatedly. He is brought in by someone who says that he has just fallen 10 feet from a ladder and hit the back of the head on a concrete path. This patient may also have a laceration, but that will not be your first concern.

The concept of 'minor' has hazards in relation to head injury:

- A head injury is only minor retrospectively, when it has settled. The precautions which you take in the first stages after injury are only rational if you accept that you are not certain that the injury is minor.
- As an emergency nurse practitioner (ENP) you have a limited exposure to minor head injuries. You are worried that the patient has an intracranial bleed and you will be content if that is not the case. Many patients who do not have a bleed go on to have chronic problems which are classified as belonging to a category called 'minor' head injury. The care of, and the study of, these patients has generated a literature on minor head injuries which defines them quite differently from your initial criteria. NICE advises that patients should be given advice on the possibility of later complications and on help and support for that eventuality.

NICE head injury guidelines are based on Canadian head CT rule, which has isolated a group of factors which are clear indicators that head CT is required: the requirement for CT scan is equivalent to the concern that the patient has an intracranial bleed or swelling. In cases where CT is not required, or where it is performed and is reported as clear, the risk to the patient is small enough to discharge him or her with advice and social support.

The development of guidelines for the management of patients with head injuries depends upon the interplay of two factors:

- current evidence on the features of an injury which help you to predict the outcome
- the availability, reliability and hazards of imaging.

These factors are always in flux and the guidelines will change accordingly. Keep up-to-date and be ready to modify your practice, training, advice leaflets and referral arrangements.

Fracture of the skull is not the same as brain injury, but there are two considerations here.

- A patient who has suffered a skull fracture has been subjected to enough force to produce a brain injury.
- There is a small incidence of serious, potentially fatal complications from fracture of the skull itself. An open skull fracture is a doorway for infection to enter the brain. An open, depressed skull fracture lodges a piece of bone and, possibly, other foreign matter in the brain and its protective tissues, with the risk of penetrating injury and cerebral abscess.

Nevertheless, skull X-ray has no role in the management of head-injured patients, partly because a positive finding does not alter the treatment of many patients, and also because a CT scan is of much greater value in showing

intracranial injury. An exception to the general rule is a skeletal survey of a child, which must include skull X-rays.

NICE guidelines for patients with head injuries form the basis of the Royal College of Radiologists (iRefer 7.0.1) guidelines for the use of imaging services. NICE recommends CT scans for patients with different degrees of urgency between 1 and 8 hours. In any case where a scan is necessary they also recommend that a provisional, written report from a radiologist should be available within 1 hour.

Adults with the following features require a CT scan within 1 hour of the risk being identified:

- GCS (see below) less than 13 on initial assessment in the emergency department
- GCS less than 15 at 2 hours after the injury
- suspected open or depressed skull fracture
- any sign of base of skull fracture (see below)
- post-traumatic seizure
- focal neurological deficit
- more than one episode of vomiting.

Adults with a history of a loss of consciousness or amnesia *and* any of the following risk factors require a CT scan within 8 hours of the injury:

- age 65 or older
- a history of bleeding or clotting disorders
- a dangerous mechanism of injury (struck by or ejected from a car or a fall of more than 1 metre or five stairs)
- more than 30 minutes' retrograde amnesia of events immediately before the head injury.

Children with the following features require a CT scan within 1 hour of the risk being identified:

- suspicion of non-accidental injury
- post-traumatic seizure but no history of epilepsy
- on initial ED assessment, GCS (see below) less than 14, or for children under 1 year GCS (paediatric) less than 15
- at 2 hours after the injury, GCS less than 15
- suspected open or depressed skull fracture or tense fontanelle
- any sign of base of skull fracture
- focal neurological deficit
- for children under 1 year, presence of bruise, swelling or laceration of more than 5 cm on the head.

Children with more than one of the following risk factors (and none of those above) require a CT head scan within 1 hour of the risk factors being identified:

- loss of consciousness lasting more than 5 minutes (witnessed)
- abnormal drowsiness
- three or more discrete episodes of vomiting
- dangerous mechanism of injury (high-speed road traffic accident either as pedestrian, cyclist or vehicle occupant, fall from a height of greater than 3 metres, high-speed injury from a projectile or other object)
- amnesia (antegrade or retrograde) lasting more than 5 minutes.

Children with one of these risk factors and none which require CT for a single finding should be observed for a minimum of 4 hours after the head injury. If, during observation, any of the risk factors below are identified, perform a CT head scan within 1 hour:

- GCS less than 15
- further vomiting
- a further episode of abnormal drowsiness.

Any patient, adult or child, who is on warfarin but has no other indication for imaging should have a CT scan within 8 hours of a head injury.

EXAMINATION

The history

History taking and examination are not separate when a patient has a head injury, for four reasons:

- The nerves which emerge directly from the brain are almost entirely devoted to the face: a level of observation of the patient which can be achieved during a conversation, as he or she tells you what has happened, is likely to reveal most of the defects which a formal examination of the cranial nerves would discover. This means that you should be more than usually careful about the arrangement of your environment. Sit facing the patient with lighting well directed to show the face in a symmetrical way.
- A depression of the patient's social behaviour caused by an injury, which may show itself as odd or slow responses, lack of humour or irritability. These are important changes but they can be elusive, not revealed by formal examination. They appear most readily if you invest a few minutes in a conversation. The *way* the patient tells you the history becomes a part of your examination.
- Many of the significant aspects of a head injury, the criteria upon which clinical decisions are made, cannot be demonstrated by a physical examination. They are things that the patient has to tell you. The patient's recollection of the injury, and events before and after it, are important measures of his or her condition. Allow the patient to tell you everything he or she remembers about the injury without contributions from witnesses, so that you have a clear impression of what he or she actually recalls. If you are in doubt about the account, or

if he or she cannot remember, that is the stage at which the witnesses are valuable. You may have to rely on witnesses entirely if the patient has no memory of the event. There is also the issue, if amnesia is a factor in the story, of deciding whether or not it is still present. Once again, the history is simultaneously a history and an examination.

- Your evaluation of the patient's condition is made partly by eliciting clinical features of the injury. Many of these features are inconclusive, indicators only: it adds much to your evaluation to put them into the context of improvement or worsening. Make a timeline from the injury until now. The sequence of any symptoms is important. A patient who was alert at the time of injury and has become drowsy since then may have an intracranial bleed, whereas a patient whose responses are sluggish but who is better than at the time of injury may require no more than a period of observation.

A busy ENP is not always inclined to sit and chat. Time invested in the history is not wasted, for your relationship with the patient and for accurate clinical management. To patients the key sign that you are humanly interested in them is that you suspend all other activities and sit down with them. These things are always true, but in the case of a patient with a head injury it is not too much to say that you cannot make a reliable evaluation unless you have done this.

Pay attention to the concerns of relatives or friends if they feel that the patient is not behaving normally. The need to depend on such advice increases with patients whose communication is always impaired by learning difficulties, dementia or some other issue.

Assess the patient using a series of questions:

- What happened? Direction, speed, duration of force are important. A direct blow on the head from a hammer may produce a depressed fracture and intracranial damage and infection: it is less likely to cause a neck injury. A patient who is thrown off a horse or a bicycle and lands on the head is prone to neck injury.
- Was there a fall? The history of a head injury is often the history of a fall, and you should always test the patient's notion that it was an injury and not an episode of illness. The elderly are a particular worry in this regard because they may suffer a serious illness such as a myocardial infarction without typical symptoms, and they may present as confused for reasons of long-standing or acute illness as well as trauma.
- Was the patient knocked out? Ask any witnesses what they saw. For how long was the patient unconscious? Ask the witness what is meant by 'unconscious'. Sometimes it is assumed that the patient who fails to get up is unconscious. Ask if the patient moved, spoke, changed colour, vomited, had difficulty breathing, showed signs of a fit?
- Was there, is there still, any memory loss caused by the injury? Retrograde amnesia refers to forgotten events before the injury and a loss of 30 minutes or more is regarded as significant. Antegrade amnesia refers to events after the injury until now and a loss of 5 minutes or more is significant. The duration of antegrade amnesia is a measure of severity of trauma and is correlated to diffuse brain injury. The patient may be able to remember isolated incidents while suffering from amnesia. Antegrade amnesia is measured as the time from the injury until continuous memory returns. It may be possible to establish that antegrade amnesia has occurred when speaking to the patient but it may not be clear whether it has ended. Give the patient some simple information which you can ask for later to assess recall.
- Was the patient using alcohol or drugs? Any use by the patient of alcohol or drugs at the time of the injury will make it difficult to assess the significance of a knockout, drowsiness, disorientation, period of amnesia, headache or vomiting, and it will make the results of examination unreliable. Local protocols or guidelines are likely to require referral so that the patient can be admitted to hospital for observation. The safe default position for the assessment of an intoxicated patient with a head injury is that any symptoms which the patient shows are caused by the injury rather than the substances taken.
- Are there any visual problems, especially double vision (diplopia) or blurring of vision since the injury, and are things better or worse? Blurry vision after a head injury is often a minor and transient problem. However, there are dangerous possibilities: double vision can be caused by a local injury to the orbit, or the pressure of a skull fracture on a cranial nerve. Orbit injury is usually accompanied by local signs, bruising and swelling. Blurring of the vision in one eye may also have a significant cause: compression of the optic nerve behind the eyeball by bleeding (retrobulbar haemorrhage) may cause blindness if surgery is not performed quickly.
- Does the patient have a headache? It is hard to imagine a head injury without some degree of headache. Headaches frequently cause concern not because of their presence but because they do not settle, because they get worse and because they are not relieved by painkillers. However, a severe headache, or one which is accompanied

by other features such as drowsiness, confusion or vomiting, is of immediate concern. A patient will usually complain of local pain at the site of the injury. This should be assessed to exclude a fracture. You should also assess the neck. If the patient is sent home, advise a return if a headache is not settling. A patient who presents in the days after a head injury with a persistent headache which does not respond to painkillers should be referred to the ED even if every other aspect of the examination is normal.

- Is there a discharge of fluid from nose or ear, or blood from the ear? This may indicate a base of skull fracture, with leakage of CSF. The other signs of base of skull fracture are bruising below one or both (usually both) eyes; redness without a posterior margin on the surface of the eye; and a bruise on the mastoid process called 'Battle's sign'. Indirect clinical evidence of base of skull fracture is important because the base lies behind the face and is inaccessible to direct examination.
- Does the patient have vertigo? This is dizziness caused by moving the head. This may be related to a fracture of the petrous temporal bone. This bone houses the osseous labyrinth of the inner ear and injury may also cause deafness and tinnitus. There should be other signs that a significant head injury has occurred.
- Has the patient vomited? Repeated vomiting may be associated with a significant head injury. It can also be a problem in its own right, especially in a child, who may become dehydrated.
- Does the patient feel any pain or restriction in the neck? Ask if the patient has noticed any weakness or loss of sensation in the limbs or any difficulty walking.
- Is there any history of allergies? What is the patient's tetanus status if there is a wound, and what are the medical history, medical problems and medications? A patient who is on anticoagulant therapy is at a higher risk of an intracranial bleed and should be referred to the ED.

The physical examination

Your examination is directed to any change in intracranial function which may indicate a significant injury:

- Record the patient's Glasgow Coma Scale and Score (see below and Table 12.1) and vital signs. Abnormal vital signs caused by the head injury are not likely if the patient seems well but a baseline will be useful if there is deterioration.
- Observe the patient coming from the waiting room. Evidence of a focal or general disturbance of movement and coordination will be available from both the gait and the ability to perform simple tasks such as standing up and sitting down. You may also pick up signs of confusion, anxiety or irritability.
- Settle the patient comfortably on a trolley with a good light source and look carefully at the injury. Remember that any injury above the shoulders requires an assessment of everything above the shoulders. Look at the posture of the neck, look for injuries and neurological changes shown in the face and search for signs of base of skull fracture (described above). Look for discharge from the ears and nose. Do not put an auroscope into a bleeding ear: you will see nothing but blood and you may increase the risk of intracranial infection if there is a fracture of the skull. Explore the scalp for swelling, boggy areas and wounds. The hair can hide injuries to a remarkable extent. The care of scalp wounds is discussed in Chapter 16.
- Ask the patient to show the full range of active neck movements. Note any restriction, especially in rotation (see Chapter 14) and ask if these movements trigger any symptoms such as headache, dizziness, tingling or radiating pain into the arms. Palpate the cervical spine for tenderness and note any tenderness, especially in the posterior midline (see Chapter 14). Carry out a neurological assessment of the limbs as described in Chapter 14.
- Examine the cranial nerves as described below. The cranial nerves emerge in pairs from the two sides of the brain, mainly to supply the sensory organs in the face and the face itself. A head injury can cause direct damage to cranial nerves and compression caused by swelling of the brain or bleeding may also have an effect. An isolated cranial nerve deficit in a patient whose examination is otherwise normal may be an incidental finding but seek advice on any such feature and document it.

The Glasgow Coma Scale (GCS)

The Glasgow Coma Scale (and the Glasgow Coma Score, a total obtained by adding the three numbers which comprise the scale) is a measurement of a patient's level of consciousness obtained by charting the degree of stimulation that is required to obtain a response, and the nature of the response, in three areas of activity, eye opening, verbal response and movement.

The GCS has been in use since 1974. Sir Graham Teasdale, one of its originators, leads a group which has revised it in its 40th year and has published new recommendations for its use. The GCS has unequalled value as a tool which

Table 12.1 **Glasgow Coma Scale**

CHECK	OBSERVE	STIMULATE	RATE
For factors interfering with communication, ability to respond and other injuries	Eye opening, content of speech and movements of right and left sides	Sound: spoken or shouted request Physical: pressure on finger tip, trapezius or supraorbital notch	Assign according to highest response observed

Eye opening

Criterion	Observed	Rating	Score
Open before stimulus	✔	Spontaneous	4
After spoken or shouted request	✔	To sound	3
After finger tip stimulus	✔	To pressure	2
No opening at any time, no interfering factor	✔	None	1
Closed by local factor	✔	Non testable	NT

Verbal response

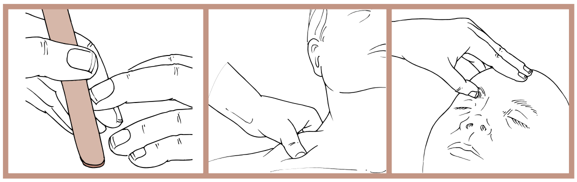
Criterion	Observed	Rating	Score
Correctly gives name, place and date	✔	Oriented	5
Not oriented but communication coherently	✔	Confused	4
Intelligible single words	✔	Words	3
Only moans / groans	✔	Sounds	2
No audible response, no interfering factor	✔	None	1
Factor interferring with communication	✔	Non testable	NT

Best motor response

Criterion	Observed	Rating	Score
Obeys 2-part request	✔	Obeys commands	6
Brings hand above clavicle to stimulus on head solidus neck	✔	Localising	5
Bends arm at elbow rapidly but features not predominantly abnormal	✔	Normal flexion	4
Bends arm at elbow, features clearly predominantly abnormal	✔	Abnormal flexion	3
Extends at elbow	✔	Extension	2
No movement in arms / legs, no interfering factor	✔	None	2
Paralysed or other limiting factor	✔	Non testable	NT

Site For Physical Stimulation

Finger tip pressure   Trapezius pinch   Suborbital notch



Features of Flexion Responses

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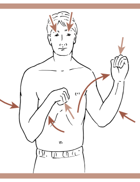
Ned Tijdchr Geneeskd

Abnormal flexion
Slow sterotyped
Arm across chest
Forearm rotates
Thumb clenched
Leg extends



Normal flexion
Rapid
Variable
Arm away from body

Courtesy of glasgowcomascale.org

can measure and communicate the level of injury to a damaged brain and the progress of an injury over a sequence of readings.

The GCS is not difficult to apply but it requires correct technique and consistency between different users. An updated chart for scoring is shown in Table 12.1. A brief discussion of some key changes follows here but a website, glasgowcomascale.org, offers indispensible resources for you to master the details of implementation.

The GCS applies to patients above 5 years of age. Charts are available for younger children at different stages of development but a non-specialist can find them difficult to score. The **Alert, Voice, Pain, Unresponsive** (**AVPU**) score is useful for a quick assessment and paediatric services prefer a non-specialist to make a quick assessment and refer the patient rather than lose time struggling with an unfamiliar scoring system.

Some of the key changes to the GCS scoring system include the following:

- In the first category, eye opening, 'sound' rather than a command is now the next level of stimulation if the patient does not open the eyes spontaneously. Below that the next level of stimulus is through pressure on a fingernail bed.
- In the second category, verbal response, the patient has to give three tokens of orientation to score 5, name, place and month. A failure with one of them reduces the score to 'confused' if the patient can still converse in coherent sentences. If the patient cannot make sentences the score is marked as 'words'. If utterances are not intelligible as words, the score is 'sounds'.
- The highest score for motor response requires that the patient demonstrates that he or she has responded voluntarily, rather than by a reflex, to a command: therefore a two-part response such as 'squeeze my hand and let go' or 'put out and put back your tongue' is elicited.

The GCS should be implemented in a sequence of steps (see Table 12.1):

- **Check** that there is no extraneous factor which might alter a score other than the brain's level of consciousness. This can include other injuries, a different language, drugs or alcohol effects and medical treatments such as intubation.
- **Observe** the patient's response to stimulation.
- **Stimulate** the patient in an escalating progression to a point where it is agreed that the response is absent. A pressure stimulus to the nail bed is used for eye opening, but a central stimulus above the shoulders, to the trapezius or supra-orbital notch, is required to elicit a localising response in movement testing.
- **Rate** the response as a score on the chart using the patient's best response.

Cranial nerve assessment (Box 12.1)

The cranial nerves originate in the brain and emerge through the cranium from there in 12 pairs, numbered from front to back, to regulate activity at external sites in the face, neck and shoulder. They carry sensory information to the brain (afferent fibres) and motor instructions from the brain (efferent fibres). The olfactory and optic nerves (numbers I and II) emerge from the forebrain and the 10 remaining nerves from the brainstem. Not all cranial nerves are equally prone to suffer injury as a result of trauma to the head.

Three themes recur in the examination of the cranial nerves:

- Our assessment of a cranial nerve is based on visible evidence, usually in the face, that it is working. However, injuries to the face itself, as well as to the nerve, can cause deficits such as an unresponsive pupil or double vision, and we must distinguish between these two.
- If the passage to a nerve is blocked (for example by blood, wax or swelling) this may cause a poor response although the nerve is not injured. This is called a conduction deficit. Check for any signs of obstruction before you carry out a test. Look into ears and nose for blockage, check that there is no blood in the anterior chamber of the eye.
- A test must isolate one side so that the other side is not stimulated. If you offer the patient a scent or a sound on the right side which can be detected on the left then the test is not valid. Therefore close the left nostril when you test the right and use soft sounds like the rubbing together of two fingers beside the ears. When shining a light into the eye, do so from the side so that it does not touch the opposite pupil.

The discovery of a deficit in a cranial nerve must be interpreted in the context of the overall clinical presentation. Examination occasionally reveals a pre-existing cranial nerve deficit or a separate problem not linked to the head injury. An isolated finding in a patient who has no other signs of a serious problem may well have no worrying significance. Take advice on any deficit but assess the whole clinical picture before doing so.

Cranial nerve I: olfactory

The olfactory nerve is a sensory nerve, for smell. Testing the sense of smell should be done one nostril at a time, with the other one held closed with a finger. Injuries to the head or

Box 12.1 Summary of examination of the cranial nerves

I (Olfactory)

- Smell – test each nostril separately

II (Optic)

- Reading print
- Pupils – direct and consensual
- Fundi
- Fields
- Colour

III, IV, VI (Oculomotor, Trochlear, Abducens)

- Eye movements – 'Do you see double?'
- Note nystagmus
- Ptosis (III nerve)

V (Trigeminal)

- Motor – palpate temporal and masseter muscles, ask patient to clench teeth
- Sensory – touch forehead, cheeks and jaw – sharp and blunt
- *If abnormal, test temperature sensation, light touch and corneal reflex*

VII (Facial)

- Note asymmetry, tics or other abnormal movements
- Raise eyebrows
- Close eyes tightly (examiner try to open)
- Show teeth
- Blow out cheeks

VIII (Vestibulocochlear/Acoustic)

- Assess hearing each side without other side able to hear
- *If loss – test for lateralisation and compare air and bone conduction* (Weber and Rinne tests)

IX, X (Glossopharyngeal and Vagus)

- Listen to voice, check swallow, ask patient to say 'ah', check soft palate and central alignment of uvula (gag reflex only if indicated by apparent abnormality)

XI (Spinal Accessory)

- Shrug shoulders against resistance
- Look for atrophy in trapezium muscles, compare sides
- Observe sternomastoid muscles, ask patient to turn head against resistance

XII (Hypoglossal)

- Put out tongue, press against sides of cheeks and palpate externally for strength

face may produce problems which will occlude the nostrils and reduce the sense of smell without injury to the olfactory nerve. If the nose is injured and the airway compromised, or if there is blood in a nostril, then smells will not be conducted to the nerve. Look into both nostrils before testing them. The patient should close the eyes and identify different scents. Informal testing may make use of objects such as soap, perfume and fruit. Fracture of the ethmoid bone or trauma to the olfactory nerve may cause hyposmia or anosmia, a partial or complete loss of the sense of smell.

Cranial nerve II: optic nerve

The optic nerve requires the most elaborate examination of the 12 nerves. It is a sensory nerve which transmits visual impulses from the retina at the back of the eye to the brain. Examination requires an assessment of five functions, visual acuity, colour perception, pupil reaction, field of vision and an inspection of the optic disc in the fundus (fundus means the 'deep' part, the retina) for signs of papilloedema (a swelling of the disc which indicates raised intracranial pressure).

Measurement of visual acuity is described in the section on eye injuries in the next chapter.

Colour vision is assessed using charts designed for the purpose. This is usually omitted in EDs and MIUs.

Pupil Reaction

Test the reactions of the pupils. You should use the light four times. The shining of a light on one eye will cause a constriction of both pupils. The constriction on the side affected by direct light is called the **direct light reflex**. The constriction on the other side is called the **consensual light reflex**. You will examine both reflexes in both eyes. Examine the pupils in dim light. Ask the patient to look into the distance to eliminate the **accommodation reflex**, a constriction of the pupils which may occur if the patient looks at something near. Shine a pen torch on the pupils from the sides so that one eye sees the light and constriction of the other pupil is consensual. Use the torch twice and look at each eye. Observe the direct and consensual responses. If the direct response is absent, but the pupil has a consensual response, the damage is likely to be to the retina or optic nerve (an **afferent** defect, meaning towards the brain). If the pupil is fixed and dilated and lacks the direct response but has the consensual response, the damage may be to the ocular motor nerve or the ciliary ganglion (an **efferent** defect, meaning out of the brain).

Visual Fields

The visual fields can be tested using the 'confrontation' technique. Sit facing the patient within an arm's length. You will evaluate the patient's fields of vision by comparing them your own. Test each eye in turn, asking the patient to cover the other. Ask the patient to look into your left eye with his or her right eye and vice versa. The patient should not move the eye from its midline contact with your eye. Make sure that the eyebrow and nose do not obstruct vision by asking the patient to tilt the head. Use your hand at arm's length and bring it nearer, mid way between the two of you, until the patient confirms that he or she can see it. Ask the patient to detect finger movements on the periphery of the four fields (named the **upper**, **lower**, **nasal** and **temporal**). Move the finger across the field to detect central defects. To ensure that the stimulus which triggers the patient's response is the sight of the fingers, ask the patient to tell you how many fingers he or she sees. There may be defects in one or both eyes, in various patterns. Note the location and disposition of any defects. In this test you are assessing the patient's normality or otherwise by comparing his or her performance with your own. This assumes that your fields are normal and that you are fairly precise in your positioning of your hand midway between yourself and the patient. It will be difficult to evaluate the meaning of small differences, but the test should pick up a large deficit.

The examination of the fundus with an ophthalmoscope is summarised in Box 12.2.

Cranial nerves III, IV and VI: oculomotor, trochlear and abducent nerves

Cranial nerves III, IV and VI control eye movement and pupil size and are assessed together (Box 12.3). The oculomotor nerve supplies the muscles which open the upper eyelids and move the eyeball up, down and towards the nose. It influences, through parasympathetic fibres, the constriction of the pupil and focusing of the lens. Problems with that nerve will lead to impairment of the movements controlled by it, and the eye will move into lateral rotation (**external strabismus**). There may be a drooping eyelid, a divergent squint, double vision and difficulty with close focus. The trochlear nerve supplies the muscle which moves the eye downwards when adducted. This movement will be reduced by impairment. The patient may report visual problems when walking downstairs and reading. The abducent nerve supplies the muscle which abducts the eye. Impairment will cause the eye to rotate medially (**internal strabismus**) with a convergent squint.

The appearance of the patient's eyes is assessed and their movement is tested. Face the patient and ask him or her to follow your finger with the eyes alone at about 60 cm distance. Lead the eyes in the outline of a letter 'H', observing their movement and asking the patient to report any abnormal experiences. Abnormalities of appearance may include **squint**, or other defects of alignment of the eyes and **ptosis** (drooping eyelid). Observe the patient's eyes in movement, to the sides and up and down. Is the movement smooth and coordinated? You may observe **nystagmus** on movement. Fuller (1993) defines nystagmus as 'a slow drift in one direction with a fast correction in the opposite direction'. It is seen as an involuntary jerky twitching of the eyeball and it may accompany a fracture of the petrous bone. The patient may report **diplopia**, or double vision. Any defect will require further assessment.

Box 12.2 **The technique for fundoscopy**

You are examining the retina to ensure that there is no papilloedema (swelling) of the optic disc, caused by raised intracranial pressure. This is a difficult technique for which you will need help and practice.

- Ask the patient to look at the wall in a darkened room.
- Look in patient's eyes holding scope at your same-side eye and in same-side hand.
- Approach the eye looking through the scope until you see the optic disc. It is found slightly to the nasal side of centre when the patient is looking forward. Use focus wheel to make it sharp.
- Blood vessels on the retina converge on the optic disc, and there are two circles, one inside the other. There is a pink outer rim and a paler inner circle.

Box 12.3 **Cranial nerves III, IV and VI**

- Cranial nerve IV: innervates the superior oblique (SO) muscle. Allows you to move either eye down and inward.
- Cranial nerve VI: innervates the lateral rectus (LR) muscle. Allows you to move either eye laterally.
- Cranial nerve III: innervates the remaining extra-ocular muscles as well as the upper eyelid and pupil constriction. Therefore allows eye movement in all remaining directions as well as lifting of the upper lid.
- Mnemonic: SO 'IV', LR 'VI', all the rest 'III'.
- Third nerve palsy (oculomotor) causes ptosis, a divergent squint (down and out) and pupil dilation.
- Fourth nerve palsy (trochlear) causes diplopia reading and walking downstairs.
- Sixth nerve palsy (abducens) causes convergent squint and loss of lateral eye movement.

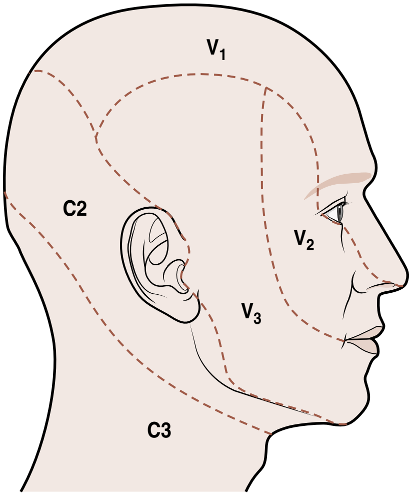


Fig 12.2 The distribution of the trigeminal nerve. (V_1) Ophthalmic division; (V_2) maxillary division; (V_3) mandibular division; C2, second cervical root; C3, third cervical root.

Cranial nerves V and VII: trigeminal and facial nerves

The trigeminal nerve has a sensory and motor function, and supplies the face (Fig. 12.2). The sensory function is in three distributions, the **ophthalmic** (including the cornea), the **maxillary** and the **mandibular**. The motor nerve supplies the muscles of mastication.

Sensory testing should be to the forehead (ophthalmic), cheek (maxillary) and chin (mandibular). Compare the two sides to light touch and sharpness.

Touching the cornea with a wisp of cotton wool will trigger a blink, the **corneal reflex**. The sensory part of this reflex is from the trigeminal nerve, and the motor response, the blink, is triggered by the facial nerve. This test is difficult to do well. The patient should not see the cotton wool and it should not touch the eyelashes. You should stand behind the patient and introduce the cotton wool from the side.

The trigeminal motor nerve can be assessed by resisting opening of the jaw with a hand placed under the chin. Ask the patient to clench the teeth and then feel the firmness of the muscles in the cheek. Ask the patient to resist your attempts to push the jaw from side to side (Box 12.4).

The facial nerve has five main branches which supply most of the motor function of the face. These can be visualised as five fingers spread against the side of the face, representing, in descending order, the **temporal**, **zygomatic**, **buccal**, **mandibular** and **cervical** branches.

These nerves supply the muscles of facial expression. They also supply the taste buds in the anterior two-thirds of the tongue. The facial nerve also supplies parasympathetic fibres to the lacrimal (tear) and submandibular (salivary) glands.

To examine the facial muscles, sit facing the patient. Observe the face for symmetry, including actions like blinking and smiling. Ask the patient to:

- lift and lower the eyebrows
- close the eyes tightly; test the muscles of the eyelids by gently trying to roll them open them against the patient's resistance ('don't let me open your eyes')
- show the teeth
- puff the cheeks.

Box 12.4 **Motor function in the trigeminal nerve**

- Look for wasting of the temporalis muscles at the temples.
- Say 'clench your teeth' and feel the tense cheeks (masseter and temporalis muscles).
- Put your thumb under the jaw and say 'don't let me close your mouth'.
- Put a finger on one side of the jaw and say 'don't let me push your chin to the side' (pterygoids), then do the same on the other side.

Cranial nerve VIII: vestibulocochlear nerve

Cranial nerve VIII has two major functions, sending sensory information to the brain from the vestibular balance receptors in the inner ear and from hearing receptors in the cochlea.

Before you assess hearing, look in the ears to exclude obvious blockage or signs of trauma. A simple test for hearing is to rub two fingertips together beside each ear and ask the patient if he can hear them equally. Equality of hearing establishes only that the patient either has normal hearing or a bilateral defect.

If there is any inequality obtain a tuning fork and perform the Weber and Rinne tests:

- For the Weber test place a sounding tuning fork (512 Hz) on the mid forehead. Ask the patient if there is any difference in the hearing of the sound, in loudness, between the two ears. If the sounds are equal you have no more to do. A difference is abnormal but, surprisingly, it is not certain that the quieter side is the abnormal one. You will decide this by proceeding to the Rinne test.
- For the Rinne test go to the louder side. Place the sounding tuning fork behind the patient's ear on the mastoid process. This conducts sound through the bone to the vestibulocochlear nerve. Ask the

patient to tell you when he or she can no longer hear the sound. Immediately lift the fork, still sounding (but do not strike it again) and hold it in front of the ear's external canal. The patient is now receiving sound through air rather than bone, which is a much more efficient process. If the louder ear is normal the patient will hear the fork again. In that case the abnormal ear is the other, quieter one, and the defect is in the vestibulocochlear nerve. If the patient cannot hear the fork on the louder side, this means that there is a conduction problem, perhaps a blockage, on that side, preventing the sound from reaching the vestibulocochlear nerve through the air. The patient hears bone conduction more loudly because the conduction blockage prevents background noise from competing with the tuning fork.

Vestibular problems will result in vertigo, poor balance, nystagmus and vomiting. The patient's ability to walk toe to heel may be checked for poor balance, with a tendency to fall towards the side of the deficit.

Cranial nerves IX, X and XII: glossopharyngeal, vagus and hypoglossal nerves

The glossopharyngeal nerve provides sensory fibres to the posterior third of the tongue, motor fibres to pharyngeal muscles involved in swallowing and the gag reflex, and parasympathetic motor fibres to the parotid salivary gland. The vagus nerve supplies a large number of efferent parasympathetic motor fibres to heart, lungs and abdominal organs, sensory fibres to the eardrum, outer canal of the ear and the ear itself, and motor fibres to the palate, pharynx and larynx. The hypoglossal nerve supplies motor fibres to the tongue. Your assessment will focus on the combined functions of these different nerves in the mouth and throat.

Look at the uvula, using a tongue depressor, and ask the patient to say 'Ah'. The uvula should rise in the midline. If it is offset to one side it is possible that there is a motor defect on the other side. The gag reflex can be tested by touching the tonsil area on each side with an orange stick – the uvula should rise in response. (This is not a test which is carried out routinely, unless an indication to do so is present. If the patient is having difficulties involving speech and swallowing you should be able to detect these from ordinary conversation as well as the patient's complaints, and this will lead you to an exhaustive assessment.) The patient's ability to taste bitter substances may be tested at the posterior third of the tongue. When assessing the larynx, ask the patient to speak, cough and swallow a glass of water. Ask the patient to stick the tongue out. Test symmetrical power in the tongue by asking the patient to push it into each cheek and pressing a finger against the cheek saying 'don't let me move your tongue'.

Cranial nerve XI: spinal accessory nerve

Cranial nerve XI is a combined cranial and cervical spinal nerve which supplies motor fibres to the sternocleidomastoid muscles of the neck and the upper trapezius.

Make resisted flexion tests of the neck for the sternocleidomastoids by pressing on the side of the head ('don't let me push your head to the side'), and on the upper trapezius by asking the patient to shrug the shoulders against downwards pressure ('don't let me push your shoulder down').

Deep tendon reflexes

A reflex is a protective mechanism, an involuntary shortcut response to a potentially threatening stimulus. In neurological terms, there is an arc, a linked afferent and efferent response. A specific stimulus to a stretch receptor in a muscle, caused by tapping the tendon with a tendon hammer, will trigger, *on every occasion*, the same motor reaction, a contraction of the muscle. Because the response is predictable and repeated, any deviation from the norm will give a useful indication that something is amiss.

Deep tendon reflexes may be abnormally active, normal, weak or absent. The method of testing five reflexes is shown in Fig. 12.3 and Box 12.5.

NICE GUIDELINES FOR DISCHARGE OR REFERRAL FROM AN MIU (BOXES 12.6 AND 12.7)

As an ENP in an MIU you will arrive at a point where you will send the patient home or transfer him or her to an ED. NICE guidelines describe three criteria for discharge, either of patients who do not require a CT scan, or whose scans have been reported as negative if the patient has been seen in the ED:

- The patient has a GCS of 15.
- There are no separate concerns, other than the head injury, which would warrant admission.
- Everything for a safe discharge, especially transport and supervision of the patient at home, is available.

There is a gap between the reach of our assessment and our knowledge of what is going on inside the patient's head, especially in those cases, the overwhelming majority, where we have not performed a CT scan. We are helped, or we appear to be helped, by the fact that very few patients who seem well in hospital will have an undetected bleed. However, this fact brings us no comfort: it is the focus of our activity to find the exceptions to the rule and our uncertainty on this matter governs our management of the whole population of patients with head injuries.

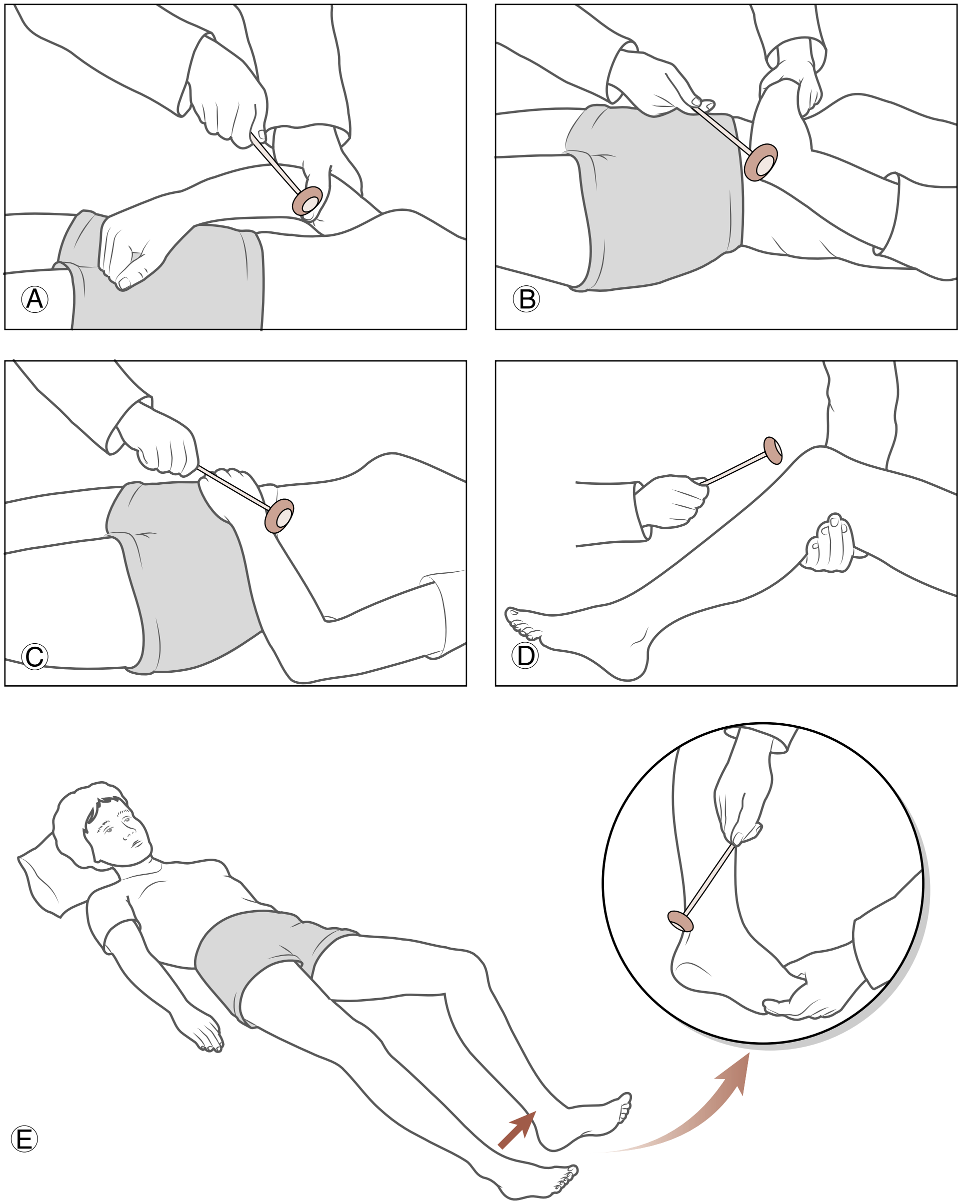


Fig 12.3 Testing for reflexes. A, Biceps jerk; B, triceps jerk; C, supinator jerk; D, knee jerk (the legs must not be in contact); E, ankle jerk.

The main device by which we bridge this gap is the assignment of the patient to a carer for the period of greatest concern, the first 24 hours after the injury. The carer has to be able to pick up any signs of deterioration in the patient and to raise the alarm. Give discharge advice to patients and to their carers, verbally and in printed form. There is a risk that if the patient deteriorates, he or she will be unable to seek help. It is therefore even more important that the carer is well prepared for the task than the patient. A reassurance from the patient that there is a vague 'someone' who can keep an eye on him or her is unsatisfactory. The patient should be collected and taken home by the carer and you should have the opportunity of speaking to that person. Patients and carers who do not speak English

Box 12.5 Testing for reflexes

- Make the patient comfortable.
- Use a tendon hammer to hit the tendon sharply.
- Watch the contraction in the muscle belly.
- Compare with other side.

Box 12.6 Required social criteria for safe discharge after head injury

- Responsible adult able and willing to supervise for at least 24 hours.
- Verbal and written instructions to that adult.
- Easy access to telephone.
- Reasonable access to medical advice.
- Transport home available.

or who have other difficulties with reading an advice sheet require specific provision. The printed advice should be age-appropriate and include:

- a description of the nature and severity of the injury
- signs of deterioration which should bring the patient back to the ED (including loss of alertness, abnormal behaviour, headache unrelieved by painkillers, vomiting, visual disturbances and a loss of feeling, power or coordination in the limbs)
- the requirement that a responsible adult should stay with the patient for the first 24 hours after the injury
- information about the recovery process and details of community and hospital services for later complications
- information about return to everyday activities, including school, work, sports and driving
- details of support organisations for patients who have suffered head injuries.

Advise the patient to avoid alcohol and sedating medicines as these can mask changes caused by the injury.

NICE offers a list of criteria for referral to ED from an MIU or other community or walk-in service of patients with head injuries whom we feel unable to discharge:

Box 12.7 Discharge advice after head injury

- Ensure a responsible adult is available to keep an eye on you for 24 hours.
- Do not take alcohol.
- Do not take sleeping pills or sedatives.
- Do not participate in contact sports for at least 3 weeks.
- There is a very small risk of complications – return to DE if specific symptoms develop.
- Mild headaches, dizziness, memory problems, poor concentration, irritability, tiredness and sleep disruption are not uncommon and generally disappear in time.

- GCS less than 15 on initial assessment
- a history of a loss of consciousness
- focal neurological deficit
- suspicion of a skull fracture or penetrating head injury
- amnesia for events before or after the injury
- persistent headache
- vomiting since the injury (there is some scope for clinical judgement on the causes of vomiting in children age 12 or under)
- seizure
- previous brain surgery
- a high-energy head injury
- a history of bleeding or clotting disorders
- on warfarin or other anticoagulant
- current drug or alcohol intoxication
- possible non-accidental injury or a vulnerable patient.

You should not be deterred from making a referral if you have concerns which are not listed above. Other factors may influence your decision, depending on your interpretation of them, including:

- irritability or altered behaviour, particularly in children under 5 years old
- any visible injury to the head which causes you concern
- a lack of home support for the patient
- continuing concern by the injured person or a carer about the diagnosis.

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Chapter 13

The face, the eye and ENT

CONTENTS

INTRODUCTION

This chapter is devoted to injuries to the face, the eye, and to the limited intersection between minor injury and ear, nose and throat (ENT) problems. Wounds to the face will be dealt with in Chapter 16. Assessment of the cranial nerves has been dealt with in Chapter 12.

Patients who present to minor injury units (MIUs) with bruised, swollen faces have often suffered nothing more serious than contusion. Nevertheless, they require careful consideration. The delicacy and importance of the structures involved, the cosmetic significance of injuries and the dangerous complications which can occur, including trauma to the nearby brain and cervical spine, are all reasons why every injury must be carefully assessed.

THE FACE

Introduction

The face has boundary lines to rival a continental map between the medical specialties that claim an interest there. The zone allocated to maxillofacial surgery lies between the eyebrow and the chin in front and the ears at the sides, excluding the eyes, ears and nose; there is a delicate demarcation between the mouth, which is shared with dentistry, and the throat, which is claimed by ENT.

In fact, maxillofacial is something like orthopaedics of the face and its main concern is with the skeleton. In terms of midline injuries this would seem to make the face an exception to the usual rule that we are not concerned about musculoskeletal problems so much as about ruling out injury to major organs. This impression is a misleading by-product of the separation of injuries into medical domains: we do indeed assess the skeleton of the face when it is injured, but that examination occurs in the context of an 'above the shoulders' assessment of head, neck and face which includes brain and spine and the delicate sensory organs of the face, not to mention the airway, and all of these take priority over a fracture of the zygoma.

The face is of unique significance for several reasons:

- It has seven openings, which give access to organs of sense (eyes, ears, nose and mouth); of these, the eyes are probably the most delicate, the most exposed and the most vulnerable to injury.
- The nose and mouth are the external part of the airway; they are used for speech, and the mouth is the upper access to the digestive tract.
- The face has a small range of movement compared with, for instance, the limbs, but it has a large supply of nerves and blood vessels, muscles adapted for fine expressive functions, and organs of sense such as the eyes and mouth.
- The face gives access to the brain by several pathways, and violent trauma to the face may also cause brain injury or injury to the cervical spine.
- Infections of the face may enter the brain.
- The signs of brain injury are likely to show in the face.
- The face is the part of the body most associated with vital psychological, social and sexual functions.

The face is intimately associated with the notion of identity. If we think about an absent person, our thought picture is of the face. The face is a repository and a source

of many subtle appearances, expressions and emanations, which seem, to other people, to show something which may be called personality, inner being or, for those who use religious language, soul. We reach all manner of relations and accommodations with other people simply by sharing a look with them: attraction, complicity, intimacy, hostility, warning, reassurance, empathy. We communicate emotion, and we conceal our feelings by the ways that we show our faces. In doing this we must have not only a response to the other person's signals but also a sense of how our expressions will be received and understood. An injury which changes our faces, alters or impedes the signals we give, reduces our attractiveness or makes us conspicuous can cause suffering, in ways that have nothing to do with the injury but are related to the **cosmetic** significance of the change. This may also mean that we are less valuable in the world of work or that we become less able to live our normal lives; these are matters which may result in litigation. It is vital, in dealing with injuries to the face, that the importance of this aspect is understood. The word 'cosmetic' sounds frivolous but, in this context, it is not.

This facial framework is a housing for delicate sensory organs and for expression and communication. It also contains the airway and the apparatus for eating and drinking. There is a great deal of movement in the face, but these movements are not for the usual purposes of the musculoskeletal system. Many of them simply rearrange the skin surface without causing activity at a joint. This means that muscle injury is limited to wounds and to crush mechanisms. The tears and strains that occur in the rest of the body are unknown. There are only two synovial joints in the face, at the junction between upper and lower jaw on each side, and the potential for ligament problems in the face is limited to these areas. This means that the range of injuries, the mechanisms of injury and the techniques for examining the musculoskeletal face, are unusually limited. Our examinations are usually addressed to the issue of whether or not a fracture has occurred, and very little else.

Many aspects of facial construction are dictated by conflicting requirements: the face displays delicate structures and protects them from injury. It is well designed to absorb certain kinds of violence and is vulnerable to others. This means that injuries have a repetitive nature, with fractures occurring at the weak points in the structure. Some of the well-known patterns of facial fracture require a severe mechanism of injury, which usually means that the patient does not appear in an MIU. The injuries seen in MIUs are the less violent ones (although they are violent enough and often occur in ugly circumstances). They usually do not involve an injury to the brain or the neck (although you will assess those), but it is more likely that there will be an injury to the eye.

Anatomy

Bone

In terms of bone structure, the frontal bone, the parietal, sphenoid and temporal bones at the sides, and the occipital bone at the back enclose the cranial part of the skull, which houses the brain (Fig. 13.1). Structures such as the orbits, the nasal structures, the zygomas, the maxilla and the mandible are facial.

Many of the joints of the skull are of an immoveable, or only slightly moveable type, and are called **sutures**.

The **orbits** are the bony sockets for the eyes. They also contain muscles to move the eyes, blood vessels and nerves and the lacrimal structures for the production of tears. They are formed by the meeting of several bones of the skull and face, the frontal above, the zygoma on the lateral aspect and the maxilla medially. In the floor of the hollow, the sphenoid, ethmoid, palatine and lacrimal bones contribute to the jigsaw of interlocking bones. There are three major openings in the bony basin: the superior and inferior orbital fissures and the optic canal. These convey nerves and vessels, including cranial nerves, from the brain to the eye and other parts of the face. On the medial side of the socket is the **nasolacrimal duct**, which allows tears to drain from the eyes into the nose.

Between the orbits, the two **nasal bones** meet in the midline of the upper face, forming the bony upper part of the nose called the bridge. Below them, the remaining nasal structures are made of cartilage. The part of the nose which divides the two nostrils is called the **septum. Paranasal sinuses** are air-filled hollows inside adjoining bones of the face; they are lined with mucosal tissue and surround and are linked to the nasal cavity.

The **maxillae** (singular, maxilla) are two bones which meet in the midline of the face above the mouth and form the boundaries of the lower parts of the orbits, the sides of the nose and the top half of the mouth. They hold the upper teeth. The maxilla is the main structure in the part of the facial skeleton known as the **middle third** (lying between the frontal bone and the mandible). The maxillary and ethmoid air sinuses lie in this area, and fractures which involve them are treated as **compound**. Backward displacement of the maxilla can compromise the airway.

The **temporal bones** are on the sides of the skull, below the parietal bones and in front of the occipital bones. They correspond, in their frontal parts, to the area called the temple. The temporal bone is subdivided into four regions. The upper part, the **squamous region**, gives rise to the zygoma (see below). The **tympanic region** is the area where the bony structure of the outer canal of the ear is found, the **external auditory meatus**. The **mastoid region** is the site of the **mastoid process**, an attachment point for muscles of the neck. This can be felt as a smooth firm bump behind the ear. The mastoid lies between the middle ear and the

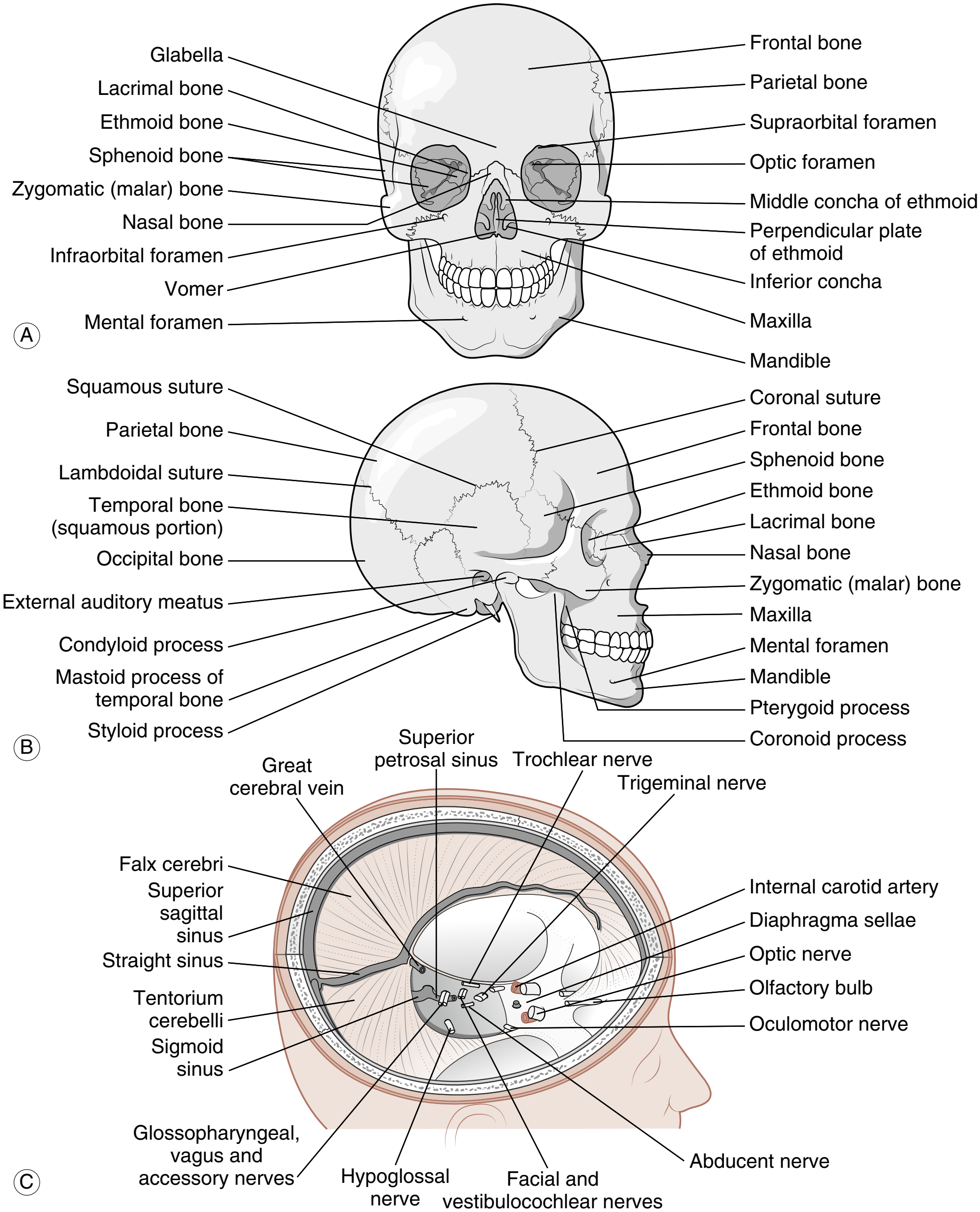

Fig 13.1 The cranial part of the skull. A, Anterior view of the skull. B, View from the right side. C, The dura mater exposed by removal of part of the right half of the skull and brain.

brain. It is an area of sinuses which can harbour infection. There is, therefore, a risk, in some cases, that ear infections can pass to the brain through the mastoid. The **petrous region** of the temporal bone forms part of the inside of the cranium and encloses the structures of the middle and inner parts of the ear.

The **zygoma** is the cheekbone. It is one of the bony structures of the middle third of the face. It arises from the

zygomatic processes of the maxilla and the frontal bone, on the lateral and inferior aspects of the orbit, and passes back along the side of the face towards the ear, as the **zygomatic arch**. It is the distinctive bony ledge which divides the temple from the cheek. It joins the **zygomatic process** of the temporal bone. Here, it forms a roof for the **temporomandibular joint (TMJ)**, the joint between the upper and lower jaws, just in front of the outer canal of the ear. There is a small hollow on the underside of the temporal zygomatic process, called the **mandibular fossa**, which receives the articulating part of the **mandible**, called the **condyle**. The external auditory meatus (see above) lies just below the zygomatic process as it merges with the temporal bone. The zygoma rises from the face and then rejoins it, in an arc something like a single-span bridge. If it suffers a crushing injury, usually from a blow to the side of the face, the span of the bone can be depressed towards the face, a fracture which creates a characteristic asymmetry, a flattening of the outline of the injured cheekbone.

The mandible is the lower jaw bone, the skeletal structure for the lower half of the mouth, the lower teeth and the chin. It comprises two symmetrical L-shaped parts which meet in the midline below the mouth (at the central dip in the chin, called the **mandibular symphysis**). The vertical legs of the bone, called the **rami** (singular, ramus, meaning branch), meet the horizontal parts at the **mandibular angle**, the posterior angle of the chin. The superior part of each ramus is made up of two processes divided by a groove called the **mandibular notch**. The anterior process is called the **coronoid**, and it is the insertion point for the **temporalis** muscle, which arises from the temporal bone and passes under the zygomatic arch to the lower jaw. It closes the mouth. The posterior process of the ramus is the mandibular condyle, which articulates with the mandibular fossa on the inferior surface of the temporal zygomatic process to form the synovial TMJ. The TMJ is a condylar joint. It allows movement at the mouth, opening and closing, lateral deviation and protrusion of the mandible (thrusting the lower jaw forward). The mandibular condyles can be felt protruding if the fingertips are placed below the zygoma, just anterior to the entrance to the canals of the ears, and the patient is asked to open his mouth. The condyles become prominent as the mouth opens, and move under the zygoma as it closes.

The muscles of the jaw

The **temporalis** passes down from the temporal bone to the anterior ramus and the coronoid process of the mandible. It participates in mouth closure, lateral movement and backward movement of the jaw from a position of protrusion.

The **masseter** passes down from the zygoma to the angle of the mandible and contributes to lateral movement and closure of the mouth.

The **pterygoid** muscles are local masticators: the medial pterygoid attaches to the medial aspect of the angle of the mandible and contributes to closure, lateral movement and protrusion of the jaw. The superior lateral pterygoid inserts at the sphenoid and neck of the condyle, anterior capsule, and the TMJ disc. It contributes to the joint activity required for chewing. The inferior lateral pterygoid attaches to the lateral pterygoid plate and the neck of the condyle. It controls condyle motion during opening and protrusion and contributes to lateral movements.

The close packed position of the TMJs is tight clenching of the teeth and the loose packed position is with the jaw hanging open a few degrees.

Movement is difficult to measure in degrees and it is usual to measure separation of the upper and lower incisors, which is usually 35 to 40 mm. A crude approximation is that the space should admit two or three fingers.

Examination

Examination is relatively straightforward. There is less emphasis on movement testing than is found in other parts of the musculoskeletal frame, and more on palpation, a fact which is consistent with our focus on fracture as the injury to exclude. The 'look' part of the assessment is always important. However, to compensate for this relative ease of examination, the interpretation of facial X-rays is uncommonly difficult.

Facial fractures can obstruct the airway, and any patient is at risk who has suffered an injury which reduces the ability to open and close the mouth or to speak properly, or which produces the sounds of obstructed breathing, stridor or snoring. A fracture of the maxilla which is displaced backwards may endanger the airway and may need prompt reduction. Blood and vomit and broken teeth may be inhaled. If teeth are missing the patient requires a chest X-ray to ensure that they have not been aspirated into the lungs.

If the airway is threatened, summon emergency help. An anaesthetist will be required, possibly to intubate the patient or perform an emergency cricothyroidotomy.

Make a neurological assessment of a patient with a face injury (see Chapters 12 and 14), checking both head and neck. Exclude other injuries, especially if the patient is elderly or very young. These are particularly common when the patient has fallen in the street or from a bicycle. Focus, in the history, on why the injury occurred, whether the patient was knocked out and whether he or she remembers the incident. Has the patient walked since it happened? Find out about past medical history and medications. Anticoagulants are of particular importance if there is a risk of cranial bleeding or bleeding within or behind the eye. Discover if there is a history of falls with an elderly person, or medical conditions which predispose to a fall, of which there are many

(the list includes Parkinson's disease, cardiac arrhythmias, arthritis, cataract, transient ischaemic attacks and diabetes). The patient's home circumstances, and whether there is someone to provide care, will be important.

A clinical examination of the face should show whether or not a fracture is present. Facial fractures often involve more than one bone, and any separate discussion of the bones should be read with that in mind.

Look for asymmetry or deformity of the face. Look from the front, the sides and from above and behind the patient, looking down. Try to distinguish a genuine bony asymmetry from soft tissue swelling and any imbalance between the sides of the face which is normal for the patient.

Other features which will alert to the presence of a fracture are tenderness, crepitus or gaps in the bone, facial paraesthesia and subcutaneous emphysema (if there is a fracture through an air sinus). There may be a loss of movement of the eye or jaw, a change in the position of the eyes in the orbits or a characteristic pattern of bruising and swelling. Fractures can occur to a number of bones.

The fractures in the mid face that are more severe, arising from violent mechanisms such as road traffic injuries, are often symmetrical, bilateral injuries to the maxilla. The fractures seen in an MIU are usually unilateral, commonly around one eye. This means that you will tend to have the advantage of a normal side for comparison in examination and on X-ray. The mandible is prone to multiple fractures, sometimes bilateral.

The lower jaw, the mandible, may be broken or dislocated at the TMJs by trauma. There is often more than one fracture:

- A significant injury will virtually always cause asymmetry. Sit in front of the patient and look at the shape of the jaw and its relationship to the middle part of the face. The philtrum, the notch in the flesh between nose and top lip, should align with the front teeth and any indentation in the centre of the chin.
- Any disruption will tend to cause an abnormal angulation of the jaw, with a consequent inability to make the teeth meet on both sides.
- Assess speech and swallowing. Look inside the lower part of the mouth for tooth injuries (tap the teeth with a metal probe to elicit tenderness), tears to the soft tissues and for haematoma. Inspect the ear for signs of bleeding.
- The condyles of the mandible usually bulge symmetrically outwards at the TMJs as the mouth opens. An inequality in this movement suggests an injury.
- A fracture will often cause paraesthesia on the lower lip on the side which is injured.
- A reduced range of movement at the TMJs is not a definite sign of fracture. Bruising in the muscles of the face will render jaw movements painful, but in this case there should be no change in the alignment of the jaw or any other sign of fracture.

Injuries

Fracture

Any patient who presents with a fracture of the face should be referred. Fractures of the face are commonly accompanied by other injuries and often occur in serious incidents such as road traffic accidents or falls from great height. The patients presenting to MIUs are of a different type. There are three common causes of injury:

- Assault: the face has been punched, kicked or struck with an implement like a baseball bat, a brick, a bottle, a hammer or a metal bar. Issues such as crime (and the injury itself represents a crime), alcohol and drug misuse and domestic violence are often related to the event, and it may be difficult to obtain a clear history.
- Sports injuries: these include blows to the face with hockey sticks and golf clubs, eye injuries from squash balls and orbit lacerations from clashes of heads at rugby. Patients who are thrown from bicycles, perhaps because they reflexively grip the handlebars as they pass over them, often fail to protect themselves with their hands, and meet the ground or a wall face-first. This mechanism of injury carries a risk of hyperextension of the neck with vertebral fracture, rupture of the anterior longitudinal ligament and injury to the spinal cord (see Chapter 14).
- Elderly people: when elderly people fall, they often fail to put out their hands and they take the impact on the face. This lack of a protective reflex implies that the injury may be the result of a collapse rather than a trip. These injuries are often eyebrow and nose lacerations with no fractures. The rim of a pair of spectacles can inflict wounds around the eyebrow. There is a risk of overlooking a fracture in the neck. Ultimately the question of why the fall happened will be likely to take more time than the facial injuries.

Blowout fracture

A blow from something small enough to bypass the bony rim which usually protects the eye can push it backwards into the orbit with explosive force. Although the movement is backwards the orbit gives way in its weakest area, which is the floor. There may be no external bony tenderness. The eye is driven into the break in the orbit and herniates into the maxillary sinus below. Clinically, a **blowout fracture** of the floor of the orbit is indicated if:

- the eye is retracted in its socket (**enophthalmos**)
- there is loss of upward eye movement on the injured side caused by 'tethering' of the soft tissues in the fracture – the pupil on the uninjured side will be visibly higher than the other
- there is double vision (**diplopia**) with one image seen above the other, the higher on the uninjured side, once again caused by tethering of the injured eye
- there is loss of sensation over the area of the infraorbital nerve (on the cheek just below the eye, side of nose, top of lip)
- there is a subcutaneous emphysema or a nosebleed on the injured side. Herniation of the eye, the fat of the orbit and perhaps the muscles of the eye into the maxillary sinus is the source of any subcutaneous emphysema.

Advise the patient to avoid blowing the nose, which can increase the surgical emphysema, and refer to the maxillofacial surgeons.

The eye can be swollen and difficult to open. The mechanism of injury makes an injury to the eye likely and it is desirable that you should examine it and record the patient's visual acuity if that can be done.

The zygoma and the rim of the orbit

A fracture of the cheekbone, often caused by assault, will tend to cause a visible or palpable depression of the bone. Comparison with the opposite side will show asymmetry.

There may be damage to vital structures within the eye; bleeding behind the eyeball (**retrobulbar haemorrhage**), optic nerve injury and damage to the orbit are common. *Assess visual acuity*. If the eye is protruding (**exophthalmos**), retrobulbar haemorrhage is possible.

Palpate the two joints between the zygoma, at the suture with the frontal bone on the outer side of the orbit, and at the maxilla below the orbit. Palpate the lower margin of the orbit. An isolated fracture of the lower margin of the orbit can occur, but you should exclude other injuries before accepting this diagnosis. Palpate the nasomaxillary and nasofrontal sutures. Assess the temporomandibular joints for disruption. All of these may be involved in the fracture. There may be paraesthesia, as for blowout fracture. A **tripod fracture** of the zygoma and maxilla is usually caused by a punch to the side of the face and is characterised by three fractures. These are found at the zygoma/frontal suture on the rim of the lateral orbit, the zygoma/maxilla suture below the orbit and the arch of the zygoma itself. This fracture disrupts the floor of the orbit.

The maxilla

The maxilla can be fractured by blunt injury, during assault or in sport (although road traffic accidents are the most common cause of fractures). These are much less common in minor areas than tripod and blowout fractures. *Assess the airway*. The maxilla may be driven back, obstructing the airway, a very violent injury. Fracture through the maxillary sinus may cause subcutaneous emphysema. Patients should not blow their noses to avoid worsening the emphysema or pushing air into the orbit. A fractured maxilla may drop down, giving the face a lengthened appearance. Maxilla fractures are accompanied by injuries to other parts of the middle third of the face, and this complex of injuries is classified in ascending order of severity as **Le Fort fractures I**, **II** and **III**.

- I: the bone containing the top teeth is separated from the face above it.
- II: the middle section of the face, including nose and the areas immediately lateral to the nose and the upper teeth, are separated from the face. The face may look elongated, and the front of the face may be mobile.
- III: the face is separated in its entirety from the cranium. This is a major injury.

The nose

The nose is often punched, and a sideways impact can easily cause a displacement to the other side, a deformity which most patients will regard as cosmetically serious.

In the initial stage, the priority of management has to do with function. Is there a severe displacement? Are the airways patent? Is there a septal haematoma which should be drained? Is there a severe nosebleed? Are there associated fractures on the face?

Be alert for the presence of cerebrospinal fluid draining from the nose, indicating a fracture of the ethmoid bone. This exposes the cranium to infection. Look also for black eyes and orbital swelling, a flattening of the nose, a very mobile fracture and facial paraesthesia.

If the nose is undisplaced, there is no wound and its functions are undisturbed, there will be no indication, from the point of view of treatment which would follow, to refer the patient for X-ray.

If there is a cosmetically significant injury which requires manipulation of the bone or cartilage of the septum, the patient should be referred to the ENT team. There will be a local arrangement for referral. This is usually postponed until the initial swelling is settled, but should be done before manipulation becomes difficult. This should be done in between a week and 10 days from the time of injury.

Inspect every nose injury for a septal haematoma and document that you have done so. The septum is the cartilage wall dividing the two nostrils. Injury will occasionally cause a bleed in the septum and a cherry-like swelling (which can come to resemble custard rather than cherry if the swelling is untreated for a few days) which bulges in

one or both nostrils. The cartilage will collapse if the haematoma is not drained with significant cosmetic issues for the patient. If you suspect a septal haematoma discuss this with ENT.

Mandible

The stability or otherwise of mandible fractures is often determined by the effects of muscle action on the broken segments. Jaw muscles can either pull the fractured parts together or separate them.

Dislocation

On occasion patients are prone to recurring TMJ dislocations with little or no injury. The condyle of the mandible moves down and then forwards out of the joint, leaving the mouth stuck partly open with an angulation of the mandible and a tendency to drool. The reduction of a dislocation is accomplished by downward pressure with the thumbs on the patient's lower back teeth to allow the condyle to return. This procedure is usually performed in an ED. It is not complicated of itself but the vulnerability of the airway and the difficulty of separating its care from the reduction process means that there are unusual hazards and you should refer the patient from an MIU. The vulnerability of the airway requires an ambulance transfer.

THE EYE

Introduction

Many eye presentations are minor ailments which do not require urgent care. There are many nurse-led services which welcome such patients. However, this book is about minor injuries and it does not offer advice on the treatment of diseases of the eye, however minor. Nonetheless, any front-door service will receive patients with eye problems. Patients with serious eye problems are usually able to walk, and it is not unknown for them to drive: they self-present to walk-in services and can be difficult to assess in an MIU. Therefore, as well as minor injuries to the eye the discussion below deviates from the policy followed in the rest of the book and includes broad advice on the triage and referral of non-traumatic problems. The referral may be to a general practitioner (GP), an emergency department (ED) or an eye hospital.

Human beings, like flowers, raise their faces to the light: blindness is a catastrophe, an elemental disaster which is not remotely described by words like disability. Take no risks with any eye problem and expect patients to be very anxious about anything which affects the eye.

Non-specialists can feel particularly insecure when dealing with eye problems. This is understandable but it should not lead you to abandon the good habits that you have established for dealing with other presentations. Take and record a well-structured history, examine the patient and think along the lines of diagnosis and severity. It is likely that you will need to consult a specialist if the problem is something beyond a corneal abrasion or sub-tarsal foreign body. A good basic history and examination will allow you to make an intelligible referral: the ophthalmologist on the other end of a telephone will have something to go on. You will create an impression of competence which does not depend upon knowing about eyes and you will receive the consideration which that earns. You will also, in a surprisingly short time, learn a good deal more about the eye.

Anatomy

Figure 13.2 shows the basic anatomy of the eye. The eyes are protected and lubricated, during reflexive blinking every few seconds, by upper and lower **eyelids**, which are joined at the medial and lateral corners of the eye, at the **canthi**. On the inner surface of the lids are the **tarsal plates**, layers of connective tissue which reinforce the fine skin of the lids. There are many sebaceous glands in the tarsal plates, and these can become blocked and develop cysts which are prominent on the surface of the lids. The upper lid is the larger of the two. The **levator palpebrae superioris** muscle (palpebrae means eyelids) lifts the upper lid to open the eye. The eyelashes have a rich nerve supply at their roots and respond to the slightest stimulus by triggering a reflexive blink. An infection of the sebaceous gland of an eyelash follicle causes a stye.

The **lacrimal gland** produces tears through the **lacrimal duct** to the upper, outer part of the eye. Tears pass across the eyeball surface before draining into the nasal cavity. Tears cleanse the eye and help to suppress infection.

The inner layer of both eyelids is covered by a thin mucous membrane, the **conjunctiva**. At the front, this membrane folds back onto the outer layer of the eyeball (the **sclera**; see below) and it merges with the epithelial layer of the **cornea**. The conjunctiva lubricates the eye. Irritation of the conjunctiva, often caused by infection or allergy, is called **conjunctivitis**. Foreign bodies often lodge in the conjunctiva of the upper eyelid.

The extrinsic muscles of the eye are shown in Fig. 13.3 and described in Box 13.1.

The eye is supported in the orbit by pads of fat and held in place at the back by the suspensory ligament. The eyeball is contained separately from the rest of the orbit by a sheet of fibrous tissue.

The eye itself has three layers:

- the sclera and the cornea
- the uvea
- the retina.

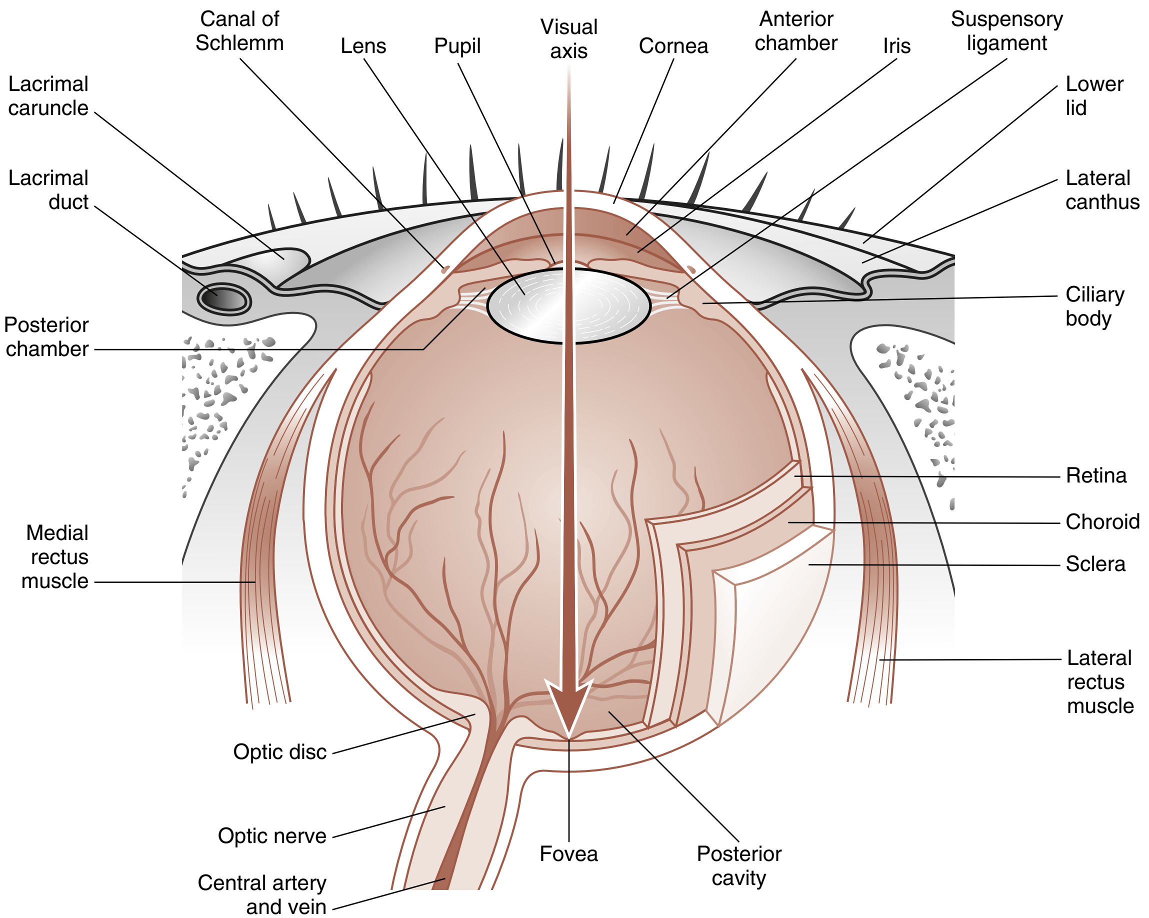

Fig 13.2 Horizontal section through the left eyeball viewed from above.

The outermost layer of the eyeball is called the **sclera** and the **cornea**. The sclera is the largest part of this layer, covering most of the globe of the eyeball except the front. It is a tough white connective tissue. The colour of this tissue gives the eye its white appearance. The tendons of the extrinsic muscles of the eye attach to its posterior area. The **optic nerve** passes through the sclera at the back, and there is a direct connection between the dura mater and the sclera. At the front of the eye, over an area which is one sixth of the globe, the sclera becomes the transparent **cornea** at the corneoscleral junction. The cornea is nerve-rich, pain-sensitive and moist, but, like the rest of the fibrous layer, avascular. The process of **refraction**, the redirection of light through the front of the eye to the retina at the back, occurs not only at the lens but also through the cornea. Because it is the front surface of the eye, the cornea is exposed to injury. Foreign bodies and wounding objects which pass the defensive blinking reflex, the **corneal reflex**, can cause **corneal abrasions** and damage to deeper structures.

The **uvea** is the middle layer of the eye. From the back of the eye to the front, it is composed of three parts, the **choroid**, the **ciliary body** and the **iris**. The choroid is a membrane which lines the sclera up to the corneoscleral junction. It is pierced by the optic nerve. It has two layers, which correspond to two functions. The outer layer has a brown pigmentation, contributed by melanocytes, which makes it light-absorbent. This prevents excessive reflection of light within the eye, which would cause confusion. The inner layer is vascular and supplies the circulation for the other layers of the eyeball. At the front of the choroid is the ciliary body. This is a ring of tissue, mainly muscle, which surrounds the lens of the eye and helps to change its shape so that it can accommodate images from different distances. The **suspensory ligament** is connected to the ciliary body and surrounds the lens, helping to maintain its position. In front of the ciliary body, and continuous with it, is the iris, the part of the eye from which eye colour is derived. The

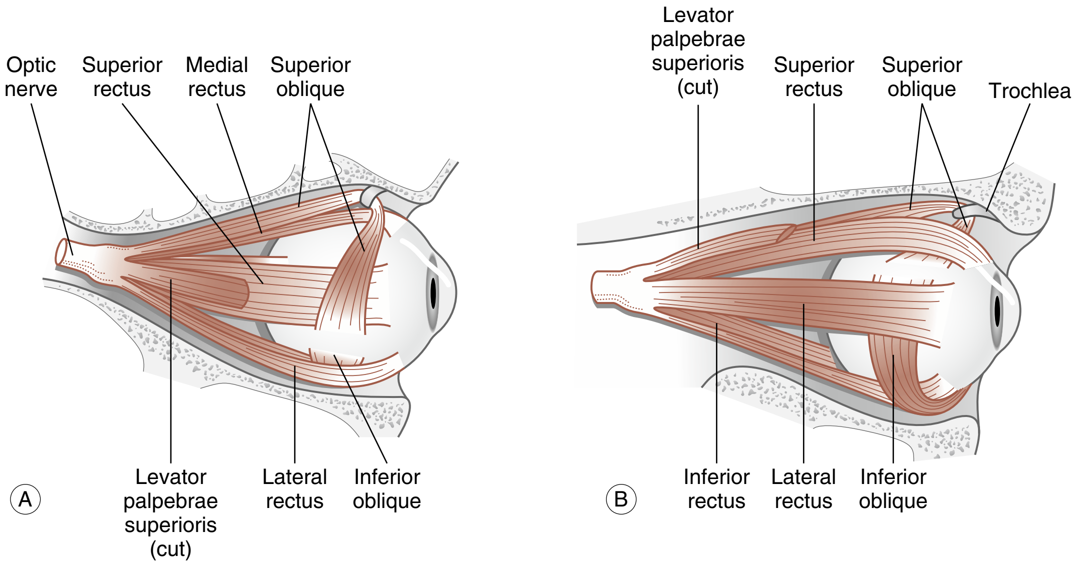

Fig 13.3 The extrinsic muscles of the right eye. A, Superior view; B, lateral view.

> Box 13.1 **The muscles of the eye**
>
> Six extraocular muscles move each eye:
> - The rectus muscles, superior (elevation), inferior (depression), lateral (abduction) and medial (adduction) attach to the sclera.
> - The oblique muscles, superior and inferior, turn the eye out and down, and out and up, respectively.
> - Cranial nerve III supplies them all except the superior oblique (trochlear) and the lateral rectus (abducens).

> Box 13.2 **The optic disc**
>
> - The optic disc is a flat circle from which the main vessels emerge. Trace a vessel if you cannot find the disc.
> - The disc has a pink outer rim and a paler inner cup.
> - The diameter of the inner cup should be half the total diameter of the disc. If it is more there may be a disease such as glaucoma.

colour of the eye depends directly on the amount of brown pigment in the iris. The iris is placed between the cornea and the lens. It is a membrane laced with two arrangements of smooth muscle fibres, one controlled by the sympathetic and the other by the parasympathetic nervous system. There is a hole in the centre of the iris, the **pupil**. The sympathetic fibres *dilate* the pupil, making it larger to allow more light to reach the lens. The parasympathetic fibres *constrict* the pupil to reduce the flow of light to the lens. This change in pupil size helps the eye to adjust to different lighting conditions. Other factors such as injury to brain, emotional state and the presence in the body of systemic or topical drugs have an effect on the size of the pupils.

The inner, third layer, of the eye is the **retina**. Like the choroid, the retina has an outer pigmented layer, with a similar function to that of the choroid. The inner layer of the retina is transparent. It contains light receptor nerve cells with two basic shapes, **rods** and **cones**. Rods deal with images received in poor light, but indistinctly with poor realisation of colour. Cones give clear, sharp, highly coloured images in good light. The optic nerve passes through the layers of the eye at the back, at a point called the **optic disc** (Box 13.2). There are no light receptors at this point, and there is, therefore, a **blind spot** in the eye's field of vision. Lateral to the optic disc is an area called the **macula lutea**, which has a small hollow in its centre, called the **fovea centralis**. This area has a very high density of cone receptors, and vision is sharpest here. Some of the blood supply to the retina is from the choroid, but the largest part is from the **central artery**, a branch of the **ophthalmic artery**, and the **central vein**, which enter and leave the eye through the passage for the optic nerve. The central artery supplies the retina in four branches, and blockage of any branch causes blindness in that area. A separation of the neural layer of the retina from the pigmented layer, usually called a **detached retina**, which may occur spontaneously or as a result of trauma, will impair vision and may cause permanent blindness if it is not repaired.

The eye is divided into two **chambers** by the lens and its supporting structures:

- The front chamber, between lens and cornea, is filled with a watery fluid called aqueous humour, a nutrient and cleansing substance which constantly enters and drains from the eye so that a consistent internal pressure of 16 mmHg is maintained. If drainage of aqueous humour is blocked, a condition known as glaucoma, increasing pressure in the eye, destroys the optic nerve and causes blindness.
- The rear chamber of the eye is filled with a transparent gel called vitreous humour. There is no circulatory change in the vitreous humour. This substance allows the passage of light, maintains the shape of the eyeball and helps to hold the various parts of the eye in place. Floaters may be visible defects in the vitreous humour, which literally float in the field of vision as spots or lines. These are a benign degenerative change. However, they may also be symptoms of a retinal detachment or a haemorrhage in the posterior chamber, and the patient should be referred to a doctor if complaining of any sudden change.

Examination

History

Your first objective with an eye presentation is to rule out anything, traumatic or pathological, which threatens the patient's sight. Decide whether you are dealing with an illness or an injury. Ask for the story of the problem. Elicit whether certain features are present:

- A loss of vision, sudden or gradual, in one eye or in both.
- Disturbances of vision including flashing lights, floaters, partial loss of a field of vision, blurring, distortion of colours and lines.
- Pain, deep or superficial, or in related areas, a headache or a pain in the temple, in one eye or two. Is the pain a superficial, gritty irritation or something deeper?
- Discomfort caused by exposure of the eye to light, photophobia.
- Is there a visible change in the eye? Is it red? Is the redness in one eye or both?
- Is there a history of injury which includes significant blunt force to the eye or a deep, or high-speed, penetrating injury?
- Is the patient unwell, are there symptoms beyond those in the eye?

Your second objective is to decide if the patient is within the scope of your practice: in an MIU this is not a long list but it does cover a large number of patients. An emergency nurse practitioner (ENP) in an MIU will manage patients with corneal abrasions, foreign bodies on the eye surface and under the lid, and will begin treatment for patients with chemical eye injuries. These are all cases where the patient presents with a history of injury.

If the patient has another problem elicit the history, carry out an examination and decide on the next step: you will have a low threshold for taking specialist advice but you will also have the option of a less urgent referral to the GP.

Elicit a general history of the patient's health, medications and allergies. A wide range of systemic illnesses can cause eye problems, with diabetes probably the best known but also including rheumatological, infective, cardiovascular, endocrine, neurological and oncological problems among others. Many systemic medicines have side effects which involve the eyes.

Does the patient have any known allergies to medicines?

What is the patient's tetanus status? Evaluate the tetanus risk as if an eye injury is a wound.

Elicit a specific ophthalmic history. Does the patient:

- use spectacles or contact lenses? If the patient is a contact lens wearer, has there been any recent problem with them, and have there been previous issues?
- have any disease of the eye? Has the current problem occurred before? In many cases the patient can tell you the diagnosis. Has the patient a history of iritis or corneal ulcers?
- take any eye medicines?
- have a history of eye surgery? A recent corneal graft? Cataract surgery?

Physical examination

Examine the eye systematically, starting externally at the eyelids and moving in stages to the deep layers.

- The eyelids and the lashes are prone to cysts and infections which often show themselves as lumps or pustules, some beneath the lid, exposed only by eversion. Deep, severe infections can involve the whole orbit and the patient may be unwell. Orbital cellulitis is a bacterial infection of the eyelid and soft tissues of the orbit. It has the potential for dangerous spread in the face and cranial cavity, and the patient may be admitted to hospital for intravenous antibiotics. Eyelashes can occasionally grow inwards and be felt as foreign bodies below the lid.
- The conjunctiva are prone to inflammation and redness, normally categorised in three groups. Bacterial conjunctivitis is an infection often caused by *Staphylococcus aureus*. The vessels of the conjunctiva enlarge, with a purulent discharge

which makes the eye sticky and difficult to open in the morning. The patient may complain of a 'gritty' feeling rather than pain. It will probably spread to the other eye. It is usually treated with chloramphenicol although it tends to be self-limiting. Viral conjunctivitis is often caused by an adenovirus. The patient may have a history of a recent cold. Both eyes will be gritty, itchy and watery, with widespread redness, deepest at the conjunctiva. It differs from bacterial conjunctivitis in appearance mainly by showing no purulent discharge. Most cases settle in 10 days or so, but some patients develop complications. It is very infectious. Allergic conjunctivitis causes conjunctival redness and swelling, corneal swelling, a clear discharge and itching rather than pain. There may be a history of a contact with a possible allergen, and the patient may have had the same problem in the past. The staple treatment is antihistamine. A sub-conjunctival haemorrhage, a small bleed visible on the sclera, is often a benign, self-limiting phenomenon but requires assessment to exclude a deeper cause, including injury.

- The cornea is prone to inflammation, called keratitis, and this is usually caused by infection, bacterial, viral or fungal. Clinical features include redness, severe pain, photophobia and discharge. There can be precipitates in the anterior chamber (hypopyon). These infections are a threat to sight, especially if a lesion is central. They can be of varying depths and can develop into corneal ulcers. Scarring of the cornea requiring graft and deep perforation of the eye can occur. The cornea, in its relatively unprotected position, is also a favoured site for injuries, especially for abrasions and for scratches caused by contact lenses. These can develop into an infectious keratitis. A careful comparison of the appearance of the eyes and consideration of history, findings and symptoms such as contact lens use, malaise, reduced visual acuity and pain will help you to assess the presentation. Fluorescein staining under a blue light will show abrasions and ulcers. Ulcers are often visible to the naked eye as milky areas on the cornea.
- The sclera may become inflamed: episcleritis is redness of the transparent superficial layer, which may be painless or feel gritty. It is not usually serious and it tends to resolve. Scleritis is a deeper and potentially serious inflammation which can cause blindness. It affects women more than men and is believed to be triggered by an autoimmune response by the body's T cells. There are different types of scleritis. Symptoms include redness, watering, photophobia, reduced vision, pain on eye movement, pain in the head and jaw adjacent to the eye and double vision. A lesion which is red or purplish, small and slightly raised is seen on the white of the eye and redness can also spread into the conjunctiva. An immediate referral is required.
- Within the eye the uvea is the area encompassing the iris, the ciliary body and the choroid. Inflammation of that area produces variable symptoms depending on the exact depth of the problem: anterior uveitis, also called iritis, is an inflammation of the combined choroid, ciliary body and iris. It can cause serious damage to the eye. The patient may have a history of rheumatological problems, or infections such as ophthalmic herpes, and may have had a previous attack of iritis. The redness is not like the redness of conjunctivitis, which tends to be deepest at the conjunctiva. It will surround the inflamed ciliary body on the rim of the iris, an appearance called ciliary flush or ciliary injection. Vision will deteriorate. The pupil may be small or irregular. Treatment is urgent. Steroids and mydriatics (drops which paralyse the ciliary muscle and thereby dilate the pupil) reduce inflammation and the pain of ciliary spasm. Intermediate and posterior uveitis tend to be less painful than iritis and to present with floaters and reduced vision. If the patient has chronic uveitis with acute flare-ups he or she will tell you the diagnosis: refer immediately.
- Deep in the eye, a variety of symptoms including flashing lights, a sudden surge of floaters, a sudden loss of a part of the field of vision ('like a curtain coming down') or a sudden development of a blind spot in one eye, can herald sight-threatening conditions such as retinal detachment and an occlusion of the retinal artery or the central vein. A vitreous haemorrhage can occur as a result of diabetic retinopathy or a retinal tear. These conditions are painless but serious and require immediate referral. The 'red reflex', the glow of the retina when a light is directed to the pupil in a darkened room (the same glow which makes an unwelcome appearance when a camera flash causes 'red-eye'), will be absent if there is something lying between the light and the fundus, if the retina is abnormal or if the pupil is constricted.
- Two conditions present with pain and an immediate threat to sight, temporal arteritis and acute angle-closure glaucoma. Temporal arteritis is a systemic disease which can occlude the ophthalmic artery and cause irreversible blindness. Symptoms include malaise, sweats, weight loss and headache at the temples increased by chewing and hair combing.

Patients tend to be older and are predominantly female. Acute angle-closure glaucoma is most likely to attack a person who is over 50 years of age and who is long-sighted. The flow of aqueous humour from the rear part of the anterior chamber to the drainage channels at the front is prevented by the lens lying too close to the iris. This causes the iris to push forward and block the drainage channels of the humour, causing a rise in intraocular pressure. There is a sudden onset of pain in the eye and temporal headache, corneal oedema, a 'muddy iris', with redness of the eye and ciliary injection, vomiting, impaired vision and haloes around lights. The pupil is fixed and semi-dilated. This condition may cause blindness, and emergency relief of the pressure is required. Medications which may be used include acetazolamide, a systemic drug which reduces the secretion of aqueous humour, and pilocarpine drops, which contract the ciliary muscle and constrict the pupil, removing the obstruction to the drainage of humour.

In summary, patients who present with a localised swelling on the eyelid or peripheral redness of the eye with mild discomfort or itching are likely to require only a non-urgent referral to the GP. Any case where there is a new loss or alteration of vision, deep or severe pain, headache with or without malaise, central redness, a lesion on the iris or sclera, changes in the iris or pupil, a loss of the red reflex, a previous history of eye problems or surgery, contact lens use and other medical problems or medicines which have a risk of eye complications requires a discussion with your on-call ophthalmology service. Take care with children and older patients.

Eye procedures

Visual acuity (Fig. 13.4)

The most basic measure of the condition of a patient's eye is of its function, which means vision, and this should be assessed in every patient with an eye complaint, and with injuries to the face and head. Apart from the contribution that this test makes to the clinical picture, eye injuries often lead to court cases, and a formal record of the patient's visual acuity should be documented.

There is nothing to gain by making people remove spectacles or lenses before testing visual acuity. The purpose of the test is to find any deterioration caused by the injury from the level of correction which the patient normally receives from lenses. Ask patients who are not wearing spectacles if they normally wear glasses or lenses (a point that should emerge during the history). People who attend with fresh injuries to the face or eye often have had to remove these because they have been broken during the incident, the face is swollen or the eye is painful. The eyes are tested one at a time. The eye which is not being tested is covered with an opaque card. Covering the eye with a hand is not adequate because it is hard to be sure that patients are not seeing through a gap in the fingers.

Fig 13.4 The Snellen letter and illiterate E test-types.
Source: Reproduced from Parr, J., 1989. Introduction to Ophthalmology, third ed. Oxford University Press.

There are visual aids for people who do not speak English, or children who are too young to read, but the standard test is of the ability to name letters on a chart. These are graded in size to reproduce the effect of reading the same size of letter from increasing distances; this avoids the need for an indefinite space to carry out the assessment. As it is, the standard test, the **Snellen**, requires 6 metres (20 feet) from patient to chart (see Fig. 13.4). If space is too small for that, a chart with reversed lettering can be hung behind the patient. Reading from that in a mirror from 3 metres (10 feet) effectively doubles the distance to the chart. It is important to test from the correct distance, and there should be a permanent mark at the 6 metre spot. The chart should be evenly lit with, preferably, a spot lamp. Some test cards are mounted with internal lighting.

The results of the test are expressed in two numbers. The first simply tells the distance to the chart in metres, 6 (when the tests were done in feet, the number was 20). The second number is based on a calculation of how a 'normal' eye, one with no error in refraction, should perform. The top letter on the chart, the largest, should be clear to the normal eye from 60 metres. A patient who can read *only* the top letter from 6 metres will have a test result of 6/60. It follows that the normal eye will achieve a score of 6/6, equivalent to the older non-metric score of 20/20. A separate result is recorded for each eye.

The top line on the chart contains only one letter. The other lines are, in descending order, smaller, with more letters, and meant to be clear from the following distances in metres: 36, 24, 18, 12, 9, 6, 5 and 4.

Patients who cannot read *any* letters from 6 metres are moved closer to the chart. If the patient can read the top letter *only* at 1 metre, this is a visual acuity of 1/60 for that eye (Boxes 13.3 and 13.4).

The patient who cannot see any letters from 1 metre is asked to **count fingers** held up by the examiner. If the patient is able to do that, the result for that eye is charted as **CF**, with the distance in metres. If the patient cannot do that but can detect the movement of a hand waving, record the result as **hand movement** (**HM**). If the patient cannot do that, shine a light into each eye. If the patient sees that, this is marked as having **perception of light** (**PL**); if not, **no perception of light** (**NPL**) is recorded.

Patients who have some kind of refractive defect of their vision will find that reading performance is improved by looking at the chart through a pinhole in a card, and this test may help the assessment of patients who arrive without their spectacles or lenses. An improvement is recorded as 'with pinhole' (with PH).

Putting in eye drops or ointment

Seat the patient comfortably and explain what you intend to do. Warn the patient if the medication is going to sting.

Box 13.3 Vision loss

- Unexplained loss requires ophthalmic referral.
- Sudden or progressive loss requires urgent referral.
- Other symptoms which worsen the outlook include eye pain; photophobia; distorted vision; flashing lights; floaters; field loss; red eye; RAPD; abnormal cornea, iris or pupil; loss of red reflex, optic disc swelling or pallor.
- Red eye with pain, photophobia or vision loss requires urgent referral to ophthalmologist. Do not treat beforehand.

Box 13.4 The red reflex

- The red reflex can be assessed with the ophthalmoscope.
- Darken the room. Remove the patient's spectacles.
- Turn the dial to 0.
- Stand at arm's length from the patient and point the scope at the patient's eye, looking through it.
- Ask the patient to look at the light. An orange glow should show in the pupil.

Eye drops can be put into the eye by asking the patient to look up and gently pulling the lower lid downwards with the tip of the finger. Put two drops into the conjunctival sac, not touching the eye with the dropper. Ask the patient to look down, then gently let the lid return to its normal position. Compress the nasal corner of the eye for 30 seconds to prevent immediate drainage of the drops into the nose.

If you are teaching the patient to insert eye drops at home ask him or her to look up and rest the barrel of the bottle on the bridge of the nose with the nozzle over the eye. Use the other hand to pull down the lower lid. Administer the drops and then press the inner corner of the eye for 30 seconds.

To put in ointment, pull the lower lid down to expose the conjunctiva and squeeze a length along the fornix (means 'the fold', plural 'fornices'): ask the patient to close the eyes for a minute or so.

Eversion of the eyelid

Eversion of the eyelid depends upon the rigidity of the tarsal plate to allow access to the conjunctiva of the upper eyelid, usually to remove a foreign body or to irrigate a chemical contaminant from below the lid. A cotton-bud stick is a suitable implement. Ask the patient to look down. Take the eyelashes between your fingers and pull the lid down and outwards. Eversion is achieved by pressing the tip of the cotton-bud stick downward on the lid just behind the tarsal plate (eversion is often done by lying the stick horizontally along the lid, but the use of the tip alone is better): turn the lid upwards, pressing down gently on the stick at the same time. The lid should fold back along the upper margin of the tarsal plate, and it should stay there as long as the patient is looking down. It will return to normal when the patient looks up and closes the eyes.

To examine the conjunctiva of the lower lid, ask the patient to look up, put your finger on the lid just below the eyelashes and pull the lid downwards.

Irrigation of the eye

Copious irrigation of the surface of the eye with an isotonic solution of normal saline is required for treatment of chemical burns (except burns from lime, a constituent of cement), and it will often remove loose foreign bodies.

The traditional irrigation vessel is the undine. It is now more common to use a bag of intravenous (IV) saline, directed through a giving set. Pull the on/off wheel down close to the external connector of the drip for accurate control of the rate of flow and direction of the stream. You need a receptacle to catch the fluid, and the patient should be wrapped to avoid wetting clothes. The patient lies down on one side with the injured eye below (there is no virtue in running the chemical over the uninjured eye) and the head over the basin. Direct the stream downwards from nose to

ear, evert both lids one after the other, and ask the patient to look up, down and to both sides while you irrigate.

A soft silicone eye-cup called the Morgan Lens which connects to an IV giving set is now the best and most effective way of irrigating the eye. The patient can lie back on a trolley, the lens slips under the lids so that there is no need for eversion and uncomfortable handling of the eye, and the corners and folds of the conjunctiva are easily irrigated. The patient may require local anaesthetic eye drops depending on how painful the injury is.

Irrigation is contraindicated if there is a protruding foreign body or a possible rupture of the surface of the eye.

Eye patches

Eye patches are less used than of old but they are sometimes helpful to give comfort for a painful eye, for instance after treatment of a corneal abrasion. A double eye patch, with the bottom layer folded double over the eye and a single layer above, held with skin tape keeps the eye closed more effectively.

The closure of one eye deprives the patient of the ability to judge distance accurately, and patients should take care and must not drive.

Eye medications

Care of minor eye injuries involves the use of three preparations:

- **Fluorescein** is a staining substance, yellow-orange in colour, which reveals corneal abrasions when the stained eye is viewed through an ophthalmoscope with a blue filter (or a slit lamp if available); it is available as an impregnated paper strip which is moistened and inserted under the lower lid or as eye drops.
- **Tetracaine** (amethocaine) (tetracaine hydrochloride 0.5% and 1%) is a local anaesthetic eye drop.
- **Chloramphenicol** ointment or eye drops are used as a broad-spectrum prophylaxis if a corneal abrasion is found or there is an active, superficial eye infection.

Eye injuries

The following discussion focuses on the eye injuries that are likely to present at an MIU. It is usually the case that the less serious cases are the more common. There are four main types of eye injury:

- chemical burns
- corneal abrasion
- blunt trauma
- foreign body: subtarsal, corneal, intraocular (penetrating injury).

Chemical burn

Splash burns to the eye with chemical substances constitute an emergency until proven otherwise. Alkaline burns are particularly destructive: burning is prolonged and the substances difficult to eradicate. Lime may linger in the eye as trapped particles in the further reaches of the conjunctiva even after a thorough irrigation. The basic elements of initial treatment are local anaesthetic and irrigation combined with an investigation of the causative chemical. Compare the pH level of the patient's eyes using litmus paper before and after irrigation: a level below 7 is acidic and above is alkaline, on a scale between 0 and 14. Copious irrigation using a Morgan lens is recommended (see above). The patient requires urgent referral to an ophthalmic surgeon.

It is vital to obtain accurate information on the burning agent. Obtain any packaging or other information that the patient has, telephone employers or suppliers. Check Toxbase and any information offered online by the manufacturer.

Corneal abrasion

A corneal abrasion is a superficial wound to the surface of the cornea, removing a part of the epithelium. It is often inflicted by foreign bodies, the leaves of plants, fingernails or claws, branches and contact lenses.

The eye is very painful and local anaesthetic is usually required before examination. Stain the eye with fluorescein and view the injury with a blue-filtered slit lamp or ophthalmoscope. A corneal abrasion will appear to be a vivid light green. A large abrasion or one which covers the central axis of vision will require clinic review to exclude permanent effects on vision and the need for a graft.

The patient should be given antibiotic drops or ointment, which will protect against infection and lubricate the eye.

If the pain does not settle, the patient should return. There is, in addition to the possibility of infection, the risk of corneal ulceration.

A **flash burn** is similar in its effect and is diagnosed and treated in the same way as a corneal abrasion. Flash burns are radiation injuries to the cornea caused by exposure of the naked eye to a sun lamp or welder's flash. Under a slit lamp one may see a peppering of pin-prick perforations on the cornea. The symptoms develop some hours after the injury. The pain can be severe.

Blunt trauma

Blunt trauma is an injury to the eye and its surrounding tissues, usually inflicted by a fist or an object like a squash ball. (A small ball is more likely to injure the eye itself than a large one, which will be deflected by the orbit.) The

patient may have a black eye, and the eye may be closed and difficult to examine. Fractures to the face, including a 'blowout' (see above), can co-exist with a blunt injury to the eye.

A first priority is function of the eye. A full test of visual acuity may not be possible, but you should try to find out if the patient can see. Check the eyeball for damage. There may be a corneal abrasion. Is there hyphaema (visible blood in the anterior chamber of the eye)? The lens may be dislocated or the iris or pupil injured. (Beware of changes in the pupils. Assess the patient as having a potential head injury.) There may be haemorrhage in the posterior chamber and detachment of the retina.

Blunt trauma has serious potential to inflict permanent vision loss and the patient requires an ophthalmology review.

Foreign bodies in the eye

Subtarsal foreign body

Typically, the patient presents with a watery, painful eye and a history of something, supposed to be grit, blowing into the eye outdoors in windy conditions. The discomfort may be localised to an area under the upper lid. If the cornea has been scratched by the grit, the discomfort may be less well localised.

Lie the patient down with the head back, and ask the patient to look down. Evert the upper lid (see above) and look for the foreign body. It can usually be lifted off with a cotton bud. The eye should be stained with fluorescein and examined under a blue filter for corneal abrasion. If this is found, a topical antibiotic is prescribed (often chloromycetin) in accordance with local practice.

Corneal foreign body

A foreign body lying on the corneal surface may be slightly embedded. The injury may have been of a higher-velocity injury than a subtarsal injury, or the patient may embed the object by rubbing the eye. It may involve something flying from a hammer and chisel or a metal grinder, and it is often a sharp piece of metal. The object is usually visible on the eye surface and can be made more prominent by side-lighting the eye. Beware of a serious intraocular injury caused by a deep penetrating foreign body, which may cause blindness.

Anaesthetise the eye with tetracaine (amethocaine) drops. Tell the patient to gaze at a fixed point. Hold the eyelids apart with one hand. A very superficial object can be lifted off the cornea with a cotton bud. An embedded object should be lifted out with the point of a sterile hypodermic needle. Use the needle point obliquely to avoid penetration of the eye if the patient moves. If it is deeply embedded, or a rust ring remains when it has been lifted out, refer the patient to ophthalmology.

Use topical antibiotic prophylaxis, as for a corneal abrasion.

Intraocular foreign body and penetrating injury

A history of a high-velocity foreign body is always, potentially, the history of a deep penetration injury into the eye. If the object is buried deep in the eye, there may be very little to see on the surface, no more than a tiny, inconspicuous entrance wound which you may not be able to see. In all of these cases, the patient will, at the very least, require X-ray examination to exclude an intraocular foreign body (IOFB). The patient may become blind if that diagnosis is missed.

A larger than normal object embedded in the cornea may penetrate to a much greater depth than its external appearance suggests. If the history suggests a large object, or if it resists removal, take care and refer the patient. Do not subject the eyeball to any pressure. If there is a projecting, penetrating object, leave it alone and make sure that the patient does the same. Make an urgent transfer of the patient to an ophthalmic surgeon.

EAR, NOSE AND THROAT (ENT)

Figures 13.5 and 13.6 show the anatomy of the nose and ear.

ENT is a specialty which encompasses deep, delicate and complex structures. To the not very great extent that it overlaps with minor injuries, the main challenge by which treatment in an MIU stands or falls is accessibility of the injury. Problems occur in tiny, dark canals lined with sensitive tissue which lead to delicate sensory mechanisms, vital organs and the airway. It is often the case that you will not have the skills or the tools which the job requires. If there is doubt refer the patient before you have made the problem worse or caused collateral trauma and fruitless distress.

ENT also encompasses the commonest minor ailments. These are not within the scope of this book.

In the MIU there are three common ENT presentations: bone and cartilage injuries to the nose (discussed above), nosebleed (**epistaxis**) and foreign bodies. Wounds around the ear and nose will be discussed in Chapter 16.

Patients will attend with a nosebleed or a recent history of repeated nosebleeds. Parents will bring children who have inserted foreign bodies into the nose or the ear, or both. Adults present with cotton-wool buds in the ear and fishbones in the throat.

Nosebleed

Nosebleeds are most common in children and the elderly. Severe arterial bleeds can be an occasional feature of adult

fractures of the nose which occur in sport after head-to-nose or head-to-knee contacts. A nosebleed feels, and looks, alarming. An elderly patient with a posterior arterial epistaxis can constitute a dire emergency. An epistaxis may be a persistent or a recurring phenomenon, either because a vessel in the nose is tending to bleed, in which case cauterisation may be the only effective treatment, or because there is an underlying medical cause, such as hypertension or a blood coagulation disorder. This would need treatment before the bleeding will stop. The patient may also, in addition to bleeding from the nose, bleed into the back of the throat and swallow blood which is later vomited.

Nosebleed which follows face or head injury may indicate a leakage of cerebrospinal fluid or a blowout fracture of the orbit. If a nosebleed follows a blow to the nose, consider the possibility of a fracture. With small children, check whether there is a foreign body in the nose.

Common causes for a nosebleed are nose picking or an infection of the upper respiratory tract, with sneezing and blowing of the nose. Bleeding, especially in children and young adults, is usually in **Kiesselbach's area**, in the anterior part of the nasal septum, and is usually venous. In older patients, the source of the bleeding can be much further back in the nose, much less accessible, and it is more likely to be arterial.

Take a history which includes any relevant medical facts, including a history of hypertension and anticoagulant medicines such as warfarin, and the frequency and duration of bleeding episodes. Check the patient's blood pressure.

If a nosebleed is anterior it will often respond to first aid. Ask the patient to:

- sit up and lean slightly forward so that blood does not go backwards down the throat
- pinch the two sides of the nose together on the soft part below the bony bridge for at least 10 minutes without interruption
- breathe through the mouth and spit out any blood in the mouth rather than swallow it.

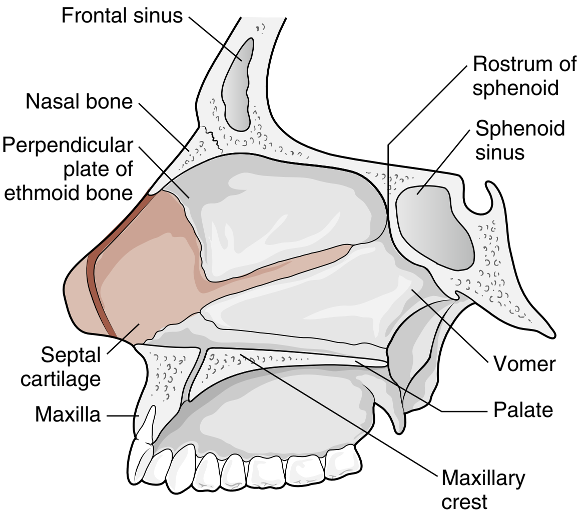

Fig 13.5 Anatomy of the nose.
Source: From Dolan, B., Holt, L., 2007. Accident & Emergency, second ed. Bailliere Tindall.

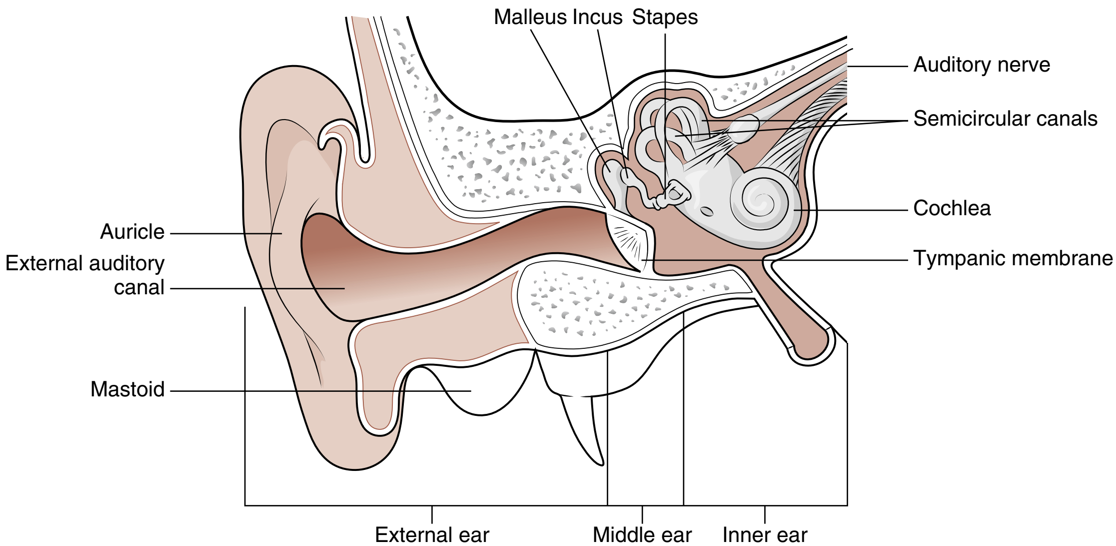

Fig 13.6 Anatomy of the ear.
Source: From Dolan, B., Holt, L., 2007. Accident & Emergency, second ed. Bailliere Tindall.

If the bleeding stops, observe the patient for a further half hour. Tell the patient not to blow the nose or otherwise dislodge the forming clot. Check the throat for back flow of blood. There are various methods, and you will have access to your own, for packing a nose to stop bleeding, including gauze packs, special tampon devices and, for posterior, inaccessible bleeds, balloon devices which can be passed, inflated and pulled forward to occlude the vessel (a Foley catheter can be improvised in these are not available).

Foreign bodies

Children often put things into the nose and ears, and a presentation with a foreign body in one orifice should lead you to check the other three. An undeclared foreign body may lie in the nose for weeks until the patient develops tell-tale symptoms: a purulent, runny nose, bad breath and alteration in the sound of the voice caused by nasal obstruction. Small beads, sweet corn, beans, pebbles and leaves are among the possibilities.

Removal of a foreign body from a child's nose or ear is a touchy business. Cooperation is difficult to obtain for work on such a delicate area. Any mishandling may make the situation worse. It can be difficult to get a child to blow the nose to dislodge the object. Children will tend to inhale, with the possibility of achieving the reverse of the desired result. There is also a small risk that a nasal foreign body will travel into the airway. If the mother is present she may be able to put her mouth over the child's mouth, occlude the unaffected nostril, and blow (the so-called 'mother's kiss'). This often dislodges the foreign body, especially if there is an adequate but not excessively tight seal. If not, at least it will do no harm. Refer patients to an ENT doctor, in line with local policy, if you are unsuccessful.

Removal of a cotton wool ball from an adult's ear can usually be done with crocodile forceps if the ball is visible. Be careful to avoid pushing the ball further into the ear and do not open the jaws of the forceps so far that they injure the wall of the canal. In general, hard, smooth foreign bodies should not be tackled with forceps: there is a greater prospect of pushing them deeper than recovering them. Tools which can pass over the object, such as the Jobson-Horne probe, perhaps with a 'lasso' loop made from a suture, may succeed in passing to its further side and drawing it forward if the passage is wide enough to allow that. Be very careful not to cause an injury. Ingenuity can achieve much but always consider the possibility of worsening the problem or causing fresh trauma.

Suction and irrigation are both useful at times. Excessive power on suction or a stiff catheter can injure the canal and the tympanum. A firmly lodged foreign body will not be moved by suction. Irrigation is carried out using the propulse machine which is also used for ear syringing: the main risk from irrigation has always been that excessive fluid pressure in the canal can rupture the tympanic membrane. The propulse machine is designed to avoid that. Do not use it if you have not been trained to do so, and avoid irrigation if you suspect that the tympanic membrane is already injured.

If an insect finds its way into the ear instil some olive oil to kill it. It can then be removed by irrigation using a propulse machine. Suction is more likely to damage it and leave parts behind. Ensure that the whole body is removed.

If a patient has a fishbone stuck in the throat, it can usually be removed with a crocodile forceps if it is visible. If it is lower down an ENT visit is required. If something larger, such as a chicken bone, is lodged, perforation of the oesophagus is a risk. The patient should be referred to ENT. Soft tissue X-rays may be requested. Some fishbones show on X-ray and others do not, depending on the type of fish. Find out what the patient was eating and consult your radiographer. The Royal College of Radiologists lists

- cod, haddock, cole fish, lemon sole and gurnard as 'radio-opaque'
- grey mullet, plaice, monkfish and red snapper as 'poorly opaque'
- mackerel, trout and salmon as 'radiolucent'.

The sensation of a foreign body may indicate a stricture or other medical problem. The sensation of a foreign body may also persist after the fishbone has come out.

Softer boluses of food which lodge in the oesophagus can sometimes be persuaded to pass on through by giving a dose of IV glucagon or Buscopan.

Teeth that have been avulsed

In descending order, the best options for a patient who has suffered a traumatic avulsion of an adult tooth and has the tooth are:

- hold it by the crown, not touching the root: rinse it under running water, place it firmly into the socket and ask the patient to bite down lightly upon it
- tuck it between the gum and cheek, so that it is bathed in saliva
- put it in milk.

The patient needs a dentist at once.

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Chapter | 14 |

The spine

CONTENTS

INTRODUCTION

In this chapter we will discuss minor injuries to the neck and lower back. Once again, as with the face, our interest is narrower than words like ‘neck’ or ‘back’ would suggest: we are interested in the spine more than anything else and the spine is the theme which links these two areas.

The neck and the back have enough in common to make their combination acceptable but there is a good deal of difference. The upper part of the spine is finer, smaller in its parts than the lower, better adapted for movement but, following the general rule that mobility is gained at the expense of safety, more exposed to violent injury. The lower back is prone to pain, not always with a tidy tale of an injury, pain which can be grumbling or cripplingly severe: a key problem with back complaints is to tell apart the sick from the injured. Extreme musculoskeletal injuries are less common in the back than the neck. The risks lie elsewhere.

These are midline injuries: you are concerned about a threat to the spinal cord more than about musculoskeletal symptoms and you are alert for illness disguised as injury. It is important to get an exact account of the injury, how it has happened and how it is affecting the patient: elicit the medical history and perform a physical examination that combines musculoskeletal and neurological elements and may extend to other systems. There are three types of injury which carry a threat in the spine, fractures, tears of the long ligaments and prolapses of the intervertebral discs. The first two are more likely in the neck and disc prolapse is a particular hazard in the upper part of the lumbar spine.

Between the neck and the back there is a significant section of spine, 12 vertebrae, half of the total number, which are connected on both sides to ribs and which are so protected and restricted by those ribs that they are almost immune from small injuries. Injuries around the ribs, which also require an assessment of the thoracic spine, will be discussed in the next chapter.

Children have vulnerabilities when the neck is injured which are discussed below. The elderly are at risk of spinal fractures as a result of pathological degeneration and trauma: this combination means that a minor injury which would cause no harm in a younger adult may result in a fracture in an elderly person. We tend to be alert for fractures around the neck and pelvis but less so when an older person has neck pain after a bump to the head or thoracic spine tenderness after a fall.

NERVE ROOT PAIN AND FOCAL NEUROLOGY

Three different factors complicate the examination of the musculoskeletal system: the capsular pattern, referred pain and nerve root pain. The first two were discussed in Chapter 5. The third is more naturally discussed in connection with the spine.

A referred pain is a pain felt in the wrong place. This occurs because of an error of perception by the brain. This phenomenon causes two problems: we do not know where the pain is really coming from and we do not know what kind of tissue is in distress. We do know that it is not bone because bone does not refer pain. In musculoskeletal terms, the solution to this difficulty is to begin in the midline of the body, either at the neck or the lower back, and to mobilise each part in turn, working outwards and

downwards into the arms or legs, until we find a movement which either increases or relieves the patient's symptoms. We should then be in the right neighbourhood and we can refine our examination to locate the culprit.

This is how we examine the soft tissues of the musculoskeletal system. However, this process also serves to examine another combination of structures which collectively form the nerve root, a sheath of dura mater wrapped around an intertwined motor and sensory nerve which is emerging from the spine through an intervertebral foramen.

This nerve root can be irritated in a variety of ways, and you are unlikely in a minor injury unit (MIU) to be sure of the cause of a problem. However, a common cause in younger adults is a lateral leakage of gel from the core of the intervertebral disc, a so-called 'slipped disc', which compresses the nerve and its sheath. Movement in the neck or back is likely to increase or relieve the pressure to some extent and the change that this causes in the pain will guide you to suspect 'nerve root' pain. The word **radicular**, which means 'root', is also used.

There can be confusion about nerve root pain and it is valuable to have a simple model of how the problem develops and escalates. If a patient has 'sciatica', with a pain passing down the back of the leg to the foot, but no numbness or weakness, this suggests that there is pressure on the sheath of dura mater, provoking its pain receptors and causing referral in the dermatomes for that level of the spine. A sciatica of that kind is not, in a strict sense, a neurological problem. The sheath wrapped around the nerve is sending the pain signal. When the nerve itself is irritated, compressed or otherwise aroused, it does not send a referred pain signal. The nerve cannot do that because, ironically, it does not have a nerve supply to send pain signals. If the pressure on the dura mater increases to the point where the nerve is also compressed, the nerve shows distress by failing in its function: sensation (in the dermatome for that level of the spine), power in the muscles supplied by that nerve or reflexes for that level of the spine are compromised. The patient shows numbness, weakness or suppressed reflexes exclusively in the path of the affected nerve. This phenomenon is called **focal neurology**.

In your diagnosis of a patient with neck or back pain you can therefore employ a model of escalation which begins with non-referred pain, then referred pain, then focal neurology and, finally, a wider distribution of neurological symptoms which suggests a more severe injury or disease. This model is a simplification: some serious spinal problems cause pain which is not referred and the spine is not the only structure which can cause urgent problems in the neck or back. However, it offers you a helpful structure for an assessment of the patient, especially when there is a clear history of injury.

More will be said on this topic in the rest of the chapter.

THE NECK

Introduction

The neck is constructed around the upper part of the spine (Fig. 14.1), which does double service as a part of the skeleton and a channel for nerves and blood vessels. Its musculoskeletal function is to attach, carry and move the head. It is also a transit point for essential services between head and body. It contains large blood vessels which supply the brain, and a multiplicity of nerves. It is also the channel to the respiratory and gastrointestinal systems. These structures emerge from and disappear into better protected areas in the head and chest, but they are superficial and vulnerable in the neck.

Physical forces which would cause no injury elsewhere, such as moderate compression or twisting, can be lethal in the neck. Wounds are very dangerous. Closed injuries which involve angulation or axial compression can be a threat to life. Serious injuries rarely arise as a result of ordinary daily activity, but injuries where the mechanism is more severe because of speed, height or violent contact, expose the neck to great danger and suddenly reveal its vulnerability.

Manage patients who present with possible neck injuries with care. Follow the guidelines and policies which are in place in your area. When there is doubt, use a hard collar and spinal immobilisation until the neck can be fully assessed.

Concern about musculoskeletal injury to the neck is focused on the cervical spine, on the bone, cartilage and ligaments. Injuries do occur to the muscles of the neck, but, in isolation, these are not dangerous, and they are probably diagnosed more often than they actually occur. The muscles of the neck are not often subjected to the complicated stresses which are common for the muscles in other parts of the body. Referral of pain is also a significant phenomenon at the neck and shoulders: pain which is felt around muscle may originate from the spine. Often the patient with discomfort at a neck muscle has gone to bed with no symptoms and wakened with pain. There is no history to suggest which tissue is causing the problem.

Displacement or destruction of a part of the spine may damage, or threaten to damage, the spinal cord. Such injuries can kill or paralyse the patient for life. Dangerous injuries may also occasionally appear to be less serious in the first instance. The presence of severe muscle spasm, so that the neck is rigid, in a patient with a significant history of injury, should lead you to suspect unstable ligament or other serious injury.

Many of the neck injuries which are classed as minor can still cause considerable difficulties. There are four common considerations:

- A neck problem may be minor in the sense that it is not a threat to life or limb, that no vital

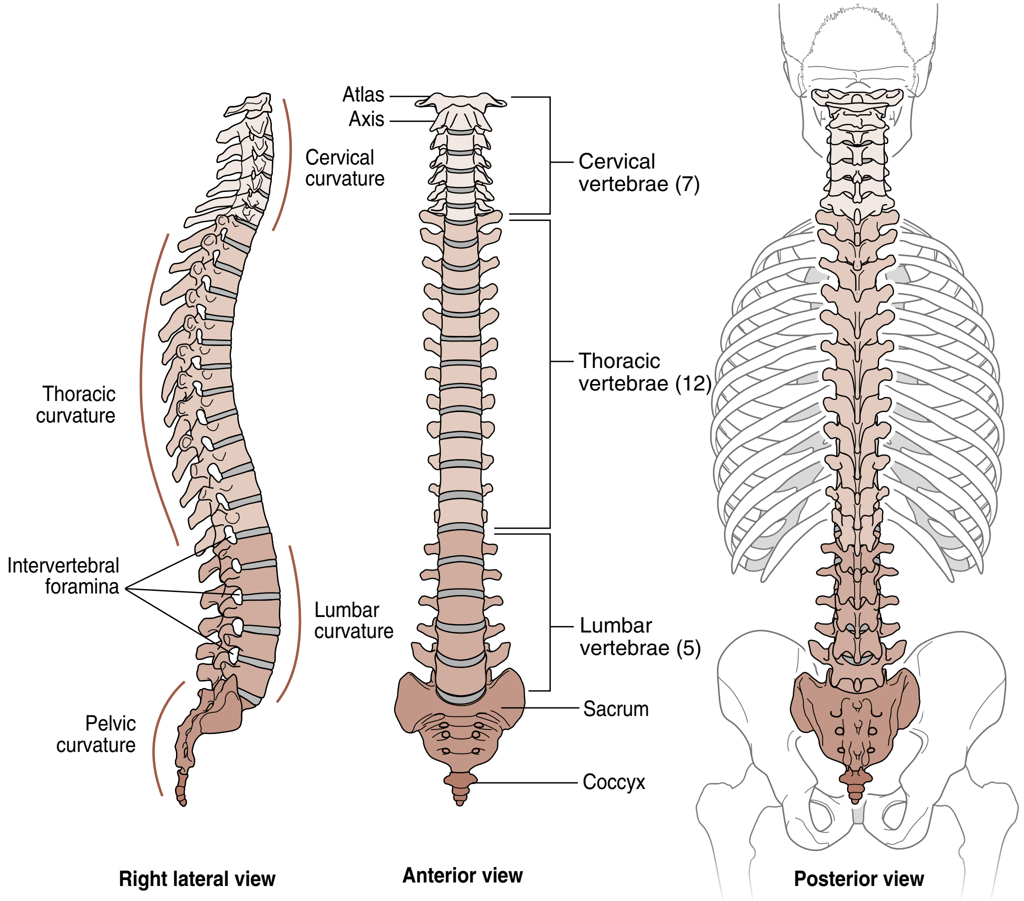

Fig 14.1 The vertebral column.

structure has been damaged, or that there is no advanced treatment to offer the patient. However, the problem may not be easy to diagnose or treat, and the patient may suffer from recurrence or prolonged pain and disability.

- Many patients who present as 'injured' with neck pain have no history of injury. You have the task of deciding whether the pain has a musculoskeletal cause, or whether the patient is ill. Is the pain referred from a vital organ, or is some other disease process, such as neoplasm or infection, causing the symptoms? This is a heavy responsibility. Have a low threshold for seeking a senior medical opinion.
- It can be difficult, when examining patients with pain in the neck and surrounding areas (including the head, the upper back and the arms), to distinguish between well-localised pain and tenderness at the site of a muscle injury, pain which is referred to those areas from the spine and the spinal nerves, and pain from other sources. The rules for assessment of those problems are the same as for the limbs, but it is difficult in a clinical setting to diagnose the cause of pain in the neck or the back. If, as it often does, the differential diagnosis includes something serious, obtain a senior medical opinion.
- X-rays of the neck are often sought by patients when they have pain, even though they are not injured. Virtually everyone who has reached middle age shows degenerative changes on a neck X-ray, whether or not they have pain. Patients who are having an acute attack of neck pain and are otherwise healthy are unlikely to gain anything from an X-ray of the neck. Focus on a thorough clinical examination to exclude non-musculoskeletal causes and to evaluate the severity of the patient's problem.

Anatomy

See Box 14.1 for a summary of the anatomy of the whole spine. The cervical section of the spine comprises the upper seven vertebrae and their ligaments and cartilage-covered intervertebral discs. It is a structure which, perhaps more than any other in the body, copes with conflicting demands. It is stable enough to support the weight of the head, yet it is the most flexible part of the spine to permit the mobility which the head requires. At the same time, it provides the armour which protects the spinal cord from damage. It also allows passage for the fibres of the cord, through a multitude of outlets, to the tissues which it supplies. The vertebral artery passes along the cervical spine to the brain.

Bone supplies the rigid elements in the spine. The vertebrae are a vertical stack of irregular bones separated in their frontal sections by pads of fibrocartilage filled with a semiliquid substance called the **nucleus pulposus** and linked in their rear sections by a succession of pairs of synovial facet joints. The pads, called **intervertebral discs**, allow flexibility between the bony parts of the spine, and they also function as shock absorbers.

The spine is arranged in a straight line when seen from the front or back, but in a series of alternating curves when

Box 14.1 The spine

- The spine consists of 26 irregular bones arranged in a series of alternating curves when seen from the side and a straight vertical when seen from front or back.
- The spine joins the base of the skull at its upper and the pelvis at its lower ends.
- It supports the head and transmits the weight of the trunk through the legs.
- It also surrounds the spinal cord and delivers spinal nerves to the whole body from exit points along its length.
- The **vertebral column** (another name for the spine) is in five sections. The **vertebrae**, the individual sections of the spine, are larger in the lower trunk because they carry more weight.
- The **cervical** spine, in the neck, has seven vertebrae. This is the most mobile part of the spine.
- Twelve **thoracic vertebrae** support the rib cage, one to each pair of ribs. They are limited in flexion and extension because the ribs limit movement, but most of the trunk's rotation occurs in this region.
- The lower back has five **lumbar vertebrae.**
- Below the fifth lumbar vertebra (L5) the **sacrum** consists of five fused vertebrae which make a bony plate linking the two sides of the pelvis to the spine and to each other.
- The coccyx is a small 'tail' of four fused vertebrae below the sacrum.
- The key ligaments of the spine run from top to bottom, the **anterior** and **posterior longitudinal ligaments.**
- The anterior ligament is attached to the fronts of the **vertebral bodies** and **intervertebral discs** from neck to pelvis. The narrower posterior ligament is only attached to the discs.
- The anterior ligament limits spinal extension, while the posterior limits flexion.
- Short ligaments join the vertebrae to their neighbours.

The vertebrae can vary in structure depending on where they are in the spine but there is a generic pattern:

- A **vertebral body** at the front is a disc of solid bone.
- Two prongs of bone pass backwards from each body to encircle a hollow called the **vertebral foramen.** When the vertebrae are stacked in a vertical line these hollows line up to provide a channel from head to pelvis called the **vertebral canal.** The spinal cord passes down from the skull through this canal.
- The two prongs which pass backwards and outwards from the vertebral bodies are called **pedicles.** They end in lateral projections called the **transverse processes**, one on each side.
- The prongs then turn inwards and backwards as **laminae** until they meet in the midline to complete the enclosure of the vertebral foramen. The laminae meet in the midline at a backwards projection called the **spinous process.**
- These processes are attachment points for ligaments and muscles.
- At the junctions of the pedicles and the laminae there are processes which project upwards and downwards, **superior** and **inferior articular processes.**
- The tips of these projections are covered with hyaline cartilage to articulate with equivalent projection from neighbouring vertebrae above and below.
- These joints are called **facet joints** (or **zagopophyseal joints**).
- There are notches on the upper and lower edges of the pedicles which create spaces between them in the vertebral column. These **intervertebral foramina** allow the passage of spinal nerves.
- Between each vertebral body is a little pad (**intervertebral** disc) which has a jelly-like centre (**nucleus pulposus**) surrounded by a strong shell of collagen and fibrocartilage (**annulus fibrosus**).
- The nucleus pulposus is springy and allows movement between vertebrae. It contributes to spinal movement and shock absorption. The annulus fibrosis limits the expansion of the inner gel and also provides anchorage points to connect the vertebrae.

seen from the side. The cervical section has a concave curve on its posterior aspect (see Fig. 14.1). The thoracic spine (the 12 vertebrae which articulate with the ribs – see Fig. 14.1) is convex. The lumbar spine (five vertebrae which lie in the lower back and link the whole structure through the sacrum, to the pelvic girdle and the lower limbs – see Fig. 14.1) is concave. The sacrum, the section of five fused vertebrae which articulates with the two wings of the pelvis at the back, is convex (see Fig. 14.1). The erect posture of the human is the result of a succession of resilient, variable, dynamic compensations rather than simple straightness, and problems with the alignment of the spine, and the balance of the structures which support it, may be a cause of chronic pain and recurring injury.

Scoliosis is a term which means that the spine has an abnormal curve to the side. **Kyphosis** means an increase in the normal convexity of the thoracic spine, seen from the side, and **lordosis** refers to the opposite phenomenon in the lumbar area, an accentuation of the curve of the lower back.

The vertebrae are similar in shape and structure along the whole length of the spine. They become larger as they descend to the pelvis. However, the first and second cervical vertebrae (Figs 14.2 and 14.3), sometimes called the upper cervical spine, are specially adapted for the task of uniting the spine to the skull and permitting the head to flex, extend and rotate.

The vertebrae of the lower cervical spine (Fig. 14.4), C3 to C7, consist of an anterior part, which is a disc of bone, the **body**, and a posterior part, the **vertebral arch**. The arch is made up of small bony processes united to form an enclosed space. Two small rods project backwards, one on each side, from the vertebral body. These are called the **pedicles**. On each side, the bony projections which begin as the pedicles continue at a new angle, still backwards but turning towards each other so that they meet in the midline, where they fuse. These projections now look flattened rather than rounded. They are called **laminae**. The space which is enclosed by the posterior border of the body, the pedicles and the laminae is called the **vertebral foramen**.

Continuing backwards from the point of fusion of the laminae there is, in the cervical region, a **bifid** (meaning, in two parts) bony projection, the **spinous process** of the vertebra. The spinous processes collectively are the most accessible parts of the spine for the examiner. They form the series of bony projections which can be felt in the midline of the back from the top of the neck to the beginning of the cleft of the buttocks.

Each vertebra also has two **transverse processes**, one projecting from each side of the vertebral body and both

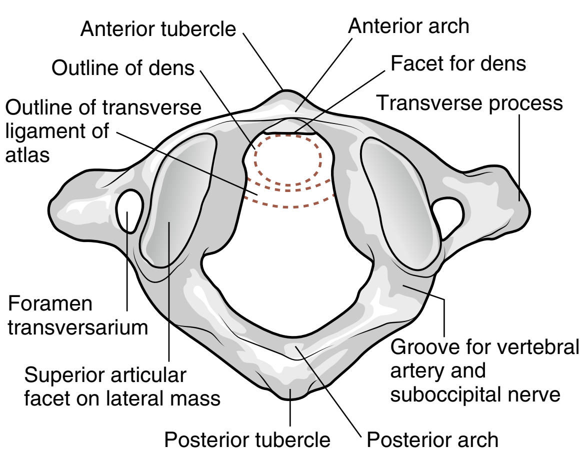

Fig 14.2 The first cervical vertebra (atlas), superior aspect.

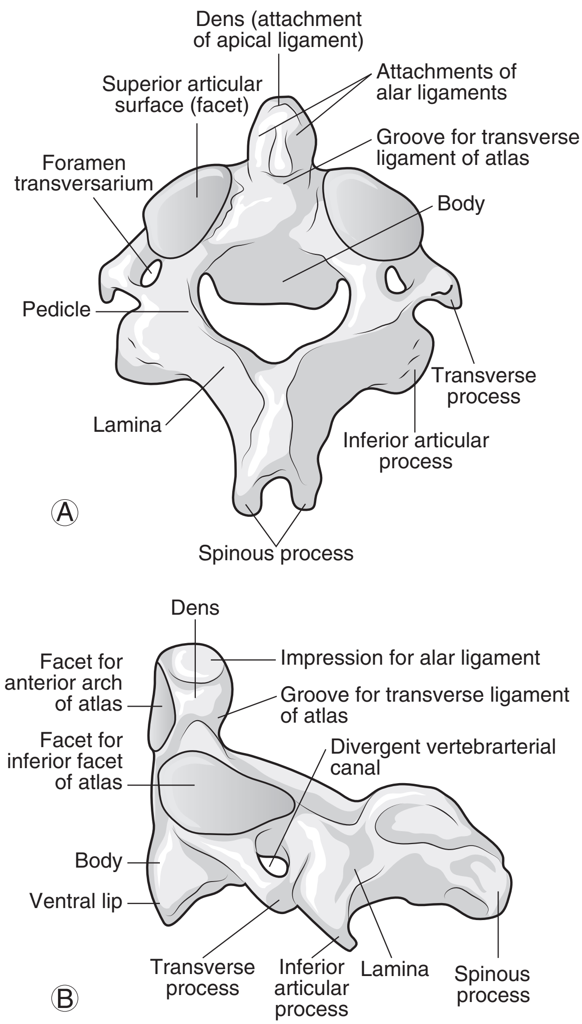

Fig 14.3 The second cervical vertebra (axis). A, Posterosuperior aspect; B, left lateral aspect.

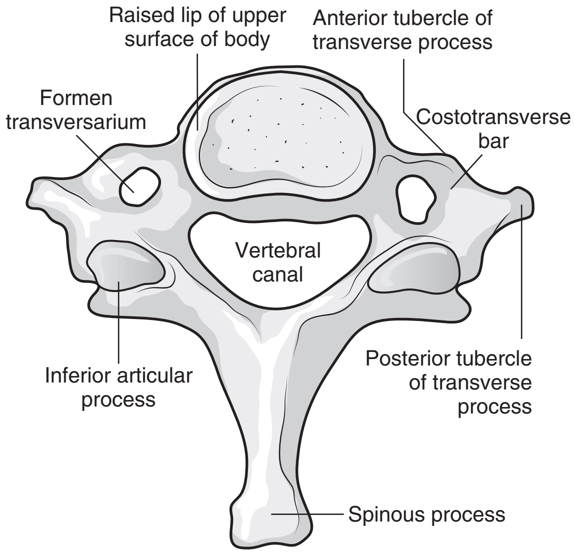

Fig 14.4 The vertebrae of the lower cervical spine: the seventh superior aspect.

pointing in an opposite lateral direction. The transverse processes of the cervical spine are unusual in having a smaller version of the vertebral foramen, a small opening called the **transverse foramen**, enclosed within each process. The vertebral artery passes up through the channel created by these openings to make its way to the cranium.

These three processes, the two transverse and the spinous in the midline, are used as attachment points for ligaments and muscles. In the thoracic area, the transverse processes are part of the articulation with the ribs at the back.

On the superior and inferior aspects of the arch, at the points where the pedicles meet the laminae, there are articular projections called the **zygapophyses**. The zygapophyses on the upper surfaces of the arch articulate with those on the underside of the vertebral arch above throughout the spine. These **zygapophyseal joints** are synovial and allow a limited amount of movement, variable from one to another. The surfaces of these articular processes, which are covered with hyaline cartilage, are called **facets**.

There are six intervertebral discs in the cervical area. These are made of a combination of three substances. There is a coating of hyaline cartilage on the opposing surfaces of the two vertebral bodies, which are linked by the disc. These are called the **cartilage end plates**. The disc proper is connected to these. The disc itself has a soft centre, a thick, jelly substance called the nucleus pulposus, which gives the disc its resilience but which can herniate if its retaining outer layer is ruptured (the event known as a slipped disc). The outer layer of the disc is an arrangement of multiple bands of fibrocartilage, the **annulus fibrosus**, which contains the nucleus.

Box 14.2 **Spinal nerves**

- Each spinal nerve within the vertebral canal has two roots, dorsal (back) and ventral (front).
- The ventral roots carry motor nerves to the skeletal muscles from the anterior horn motor neurons of the spinal cord. These are also called efferent fibres. The autonomic nervous system, which controls the activity of the organs, is another branch of the motor system and it is found in the ventral roots.
- The dorsal (**afferent**) roots are sensory neurons from the **dorsal root ganglia** of the spinal cord. The dorsal roots conduct sensory information to the spinal cord from peripheral receptors.
- Ventral and dorsal nerves join before they pass out through the **intervertebral foramen** from the vertebral canal, as a single spinal nerve root, and then they divide again into a small dorsal **ramus** (branch) and a larger ventral ramus. The rami are a mixture of motor and sensory fibres.
- The spinal nerve rami supply the muscles and the skin from the neck down. The dorsal rami supply the posterior body trunk and the ventral rami supply the rest of the trunk and the limbs.
- The ventral nerve roots are strictly motor and the dorsal roots are sensory; they combine to pass out of the spine as a *mixed motor and sensory* spinal nerve which gives rise to *mixed motor and sensory* ventral and dorsal rami.
- Except for T2–T12 the ventral rami meet in complex 'junction boxes' called **plexuses**, the **brachial** plexus at the shoulder and the **lumbar** and **sacral** plexuses in the lower back.
- The nerves pass down into the limbs from the plexuses.
- The plexuses mean that the nerves to each muscle come from different vertebrae. This reduces the impact that damage to one vertebra can have on that muscle.

There is space between the pedicles of neighbouring vertebrae for the passage of spinal nerves into and out of the spine (Box 14.2). These gaps between the pedicles are called the **intervertebral foramina** (meaning, openings between vertebrae).

The chain of vertebral foramina which is formed by the arches of the spine is called, in combination, the **vertebral canal**, and it is through this structure that the spinal cord passes from head to pelvis.

The **spinal cord** runs through the vertebral canal. It forms a part of the **central nervous system**. It is described as being divided into a series of **segments**; each segment has a pair of **spinal nerves**, and these nerves pass out into the body through the intervertebral foramina of the spine, where they form part of the **peripheral nervous system**. The parts of the spinal nerve which join the spinal cord are

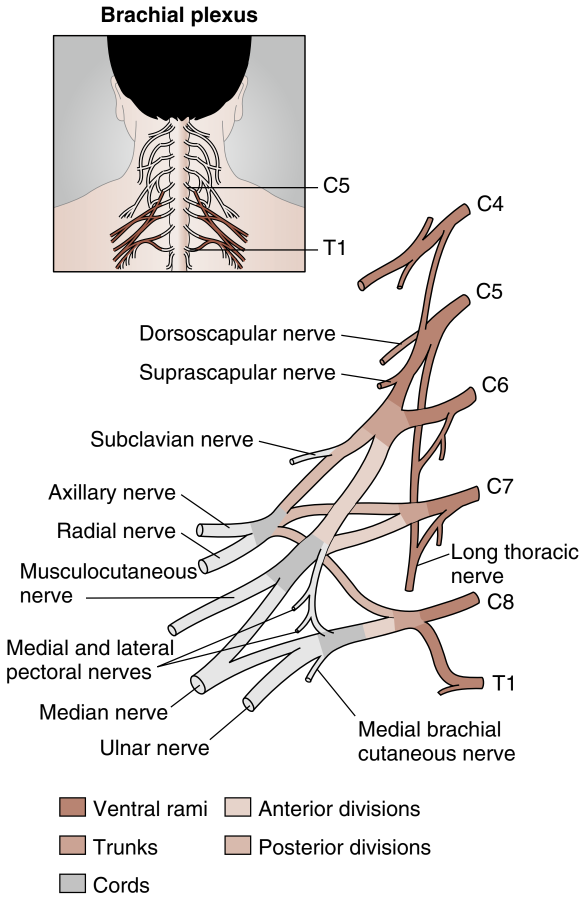

Fig 14.5 Brachial plexus. Three trunks form from the five rami (C5 to T1) and then subdivide into divisions then cords. The cords give rise to the individual nerves leaving the plexus.

called the **roots**. Each nerve has two roots, a **ventral** (front) and a **dorsal** (back) root. The ventral root carries **efferent** (from the Latin, to carry out of) motor fibres from the cord to the spinal nerve. These nerves ultimately pass to muscles and stimulate them to contract. The dorsal root delivers **afferent** (from the Latin, to carry to) sensory fibres from the spinal nerve to the cord. The cervical segments are numbered from 1 to 8. C1 to C7 nerve roots emerge from above the vertebra for which they are numbered, and C8 emerges from between C7 and T1.

The **brachial plexus** (see also **lumbar and sacral plexus**, below) is a combination into a network of the ventral nerves from C5 to T1, with exchanges of fibres between the different segmental nerves. It occurs after the nerve has emerged from the spine but before it reaches its peripheral distribution. The brachial plexus supplies the shoulder and arm with motor and sensory fibres (Fig. 14.5 and Box 14.3).

Box 14.3 The brachial plexus

- The brachial plexus lies in the lateral neck and axilla and supplies the arm. It weaves the fibres from the ventral rami from C5 to T1.
- The subdivisions of the plexus from the spine outwards are roots (*not* the spinal nerve roots), trunks, divisions and cords.
- Five **roots** from ventral rami C5 to T1 unite to create three **trunks**, **upper**, **middle** and **lower.** Each trunk divides into an **anterior** and **posterior division** to supply the front and back of the arm respectively.
- The divisions pass under the clavicle into the axilla where the six bundles become three **lateral**, **medial** and **posterior cords** (named for their positions in relation to the **axillary artery**).
- Small nerves from the upper plexus branch into the skin and muscles of the shoulder and upper chest.

The three cords pass along the axilla with the artery and give rise to the five main nerves of the arm:

- The **axillary nerve** branches from the posterior cord behind the surgical neck of the humerus. It gives motor nerves to **deltoid** and **teres minor** and sensation to shoulder skin and joint capsule.
- The **musculotaneous nerve** from the lateral cord passes down the front of the upper arm. It gives motor supply to the **biceps** and **coracobrachialis muscles** and sensation on the lateral forearm.
- The **median nerve** descends to the anterior forearm from the lateral and medial cords of the plexus and supplies skin and the pronators and the flexor muscles on the radial side of the wrist and hand.
- The **ulnar nerve** branches from the medial cord. It passes down the medial upper arm and is superficial behind the medial epicondyle of the elbow. It descends along the ulna towards the palm side to supply sensation and flexion on the ulnar side of wrist and hand.
- The **radial nerve** is the largest branch from the plexus, continuing from the posterior cord. It wraps around the back of the shaft of the humerus in the **radial groove** then passes in front of the **lateral epicondyle** of the elbow where it divides into a **superficial branch** which runs along the radial edge of the radius to the hand and a **deep branch** which lies in the posterior forearm. It supplies sensation to the whole posterior arm and its motor branches the arm's **extensor muscles.**

The intervertebral discs which lie between each vertebral body are also, on their posterior aspects, in close contact with the spinal cord, and any injury which causes a herniation of the disc in a backward direction may interfere with the function of the cord. Cyriax and Cyriax (1993) point out that the anterior dura mater covering the spinal cord

where it meets the vertebral bodies and discs, and the dura mater, which covers nerve roots as they pass out from the spine, are innervated, and pain will be felt if either is overstretched or compressed. There are two possibilities.

- A backward herniation of the disc will impinge first on the dura mater where it covers the central cord and cause extrasegmentally (meaning, not only in the dermatome for that segment of the spine) referred pain, usually on one side only (see pain referral, Chapter 5). In the cervical area, this pain may be felt in the neck, over to the forehead, or, most commonly, in the scapular and shoulder area.
- A herniation which is backwards but to one side or other, rather than central, will impinge upon the nerve root on that side, which is also covered at that point in a sleeve of dura mater. This will cause pain only if the pressure is slight but will cause signs of nerve compression (weakness, paraesthesia and reflex suppression) if the pressure is deep enough to reach the nerve within the sheath. These symptoms will refer to the dermatome for that nerve root.

Three of the cervical vertebrae have special features which require further description. C7 (see Fig. 14.4) has a larger body than the other cervical vertebrae and a longer, non-bifid, spinous process. It offers a conspicuous landmark at the base of the back of the neck, at the point of transition between the cervical and the thoracic spine. T1 is also seen, even more prominent than C7, and just below it.

In the upper cervical spine, C1, also called the **atlas** (see Fig. 14.2), after the mythic Titan who carried the weight of the heavens upon his shoulders, bears the weight of the skull. It has two articular facets on its upper surface, and the **occipital bone** lies upon them at the **atlanto-occipital joints**. These joints permit some degree of flexion and extension of the head. The undersurfaces of the atlanto-occipital joints are also adapted for articulation with the upper surfaces of C2, at the **atlanto-axial joints**. The atlas has no vertebral body or intervertebral disc. It is simply a bony ring made up of a front and rear arch, linked at the sides by its articular masses. The atlas has a transverse process on each side, which can be felt just under the mastoid processes (the prominences behind the ears) of the skull. Unlike the other vertebrae it does not have a projecting spinous process at the rear. There is only a **posterior tubercle**, a little button of bone which is difficult to palpate.

C2 (see Fig. 14.3) is also called the **axis**. It does possess a vertebral body but has a unique feature: a peg-like bony projection rises from its superior surface like a tooth (hence, its names, the **dens**, or the **odontoid process**; both derive from terms for teeth). This peg projects upwards through the arch of the atlas. It is stabilised there by ligaments, inside the **foramen magnum** (meaning, large opening) of the skull, which gives access to the cranium on the underside of the occipital bone. The **transverse ligament** crosses behind the dens and the **alar ligaments** pass from the dens to the occipital bone on each side. The atlas, and with it, the skull, rotate about the fixed point of the axis. Half of the neck's range of rotation occurs at this joint. The alar ligaments are placed to prevent excessive rotation on the side opposite to each ligament (ie, the alar ligament on the left tightens as the head rotates to the right). The alar ligament also prevents separation of the axis from the atlas. It becomes tighter as the neck is flexed. Injury which involves forced flexion and rotation of the head may rupture the ligament, allowing excessive rotation on the side which is opposite to the tear. Patients will sometimes demonstrate the frightening sense of instability which this type of injury inspires by holding onto their heads as if to prevent them from falling off.

Other ligaments stabilise the spinal column as a whole. The **anterior longitudinal ligament** is strong and passes down the front of the spine, attaching to vertebrae and to discs. It limits the range of extension of the spine. The **posterior longitudinal ligament** passes up the back of the spine, attaching to the intervertebral discs. This limits the range of spinal flexion. **Ligamenta flava**, a series of individual ligaments rather than a continuous band, reinforce the rear of the spine, linking neighbouring laminae and forming a part of the vertebral canal. In the cervical area the **ligamentum nuchae** also passes from the occipital area to the spinous process of C7.

Movement in the cervical spine is allowed and limited by the same forces, the action of the various ligaments, the disposition of the zygapophyseal joints and the mobility of the intervertebral discs, which have a capacity for compression, rotation and for stretching. In the cervical area, the discs are relatively thick, and this adds to the range of movement. The muscles of the neck offer a dynamic force for stability and mobility, and they exert a powerful protective influence when injury occurs by going into spasm to immobilise the injured area. This is one of the factors which can, initially, conceal the extent of the instability caused by an injury. Box 14.4 gives the normal cervical spine ranges of movement.

The cervical spine houses the **vertebral artery**. This is a branch of the subclavian artery. It joins the cervical spine at the transverse processes on each side of the C6 vertebra. It then passes up to enter the skull through the spine's point of access to the cranial cavity, the foramen magnum, at the back and underside of the skull in the occipital region. The two branches of the artery unite at this level to form the **basilar artery** within the cranium. This artery, along with the internal carotid artery, carries the brain's blood supply. The vertebral–basilar contribution is about one-fifth of the total. Interruption of its function may be caused, among other things, by degeneration or subluxation of the cervical spine, which may stretch or compress the vessels and will affect cerebral activity. Excessive movements of extension and rotation of the neck, common in

Box 14.4 Cervical spine statistics

The ranges of movement quoted here are the composite ranges, made up of smaller movements in different parts of the spine.

- Capsular pattern: a greater limitation of side flexion and rotation, a lesser limitation of extension.
- Joint positions: close packed is extension; loose packed is a small degree of extension.
- Flexion approximately to 90°; endfeel firm.
- Extension approximately to 70°; endfeel firm.
- Rotation occurs to each side to approximately 80°; endfeel firm.
- Side flexion occurs to each side up to approximately 45° (there is a wide variation between individuals); endfeel firm.
- Circumduction rotation of the head achieved by combining a fluent sequence of the above movements.

so-called **whiplash injuries**, may compromise the artery in the region of the foramen magnum. The pathological process will be of ischaemia in the areas supplied. Be aware of suggestive elements in a patient's history. Patients who suffer from cervical spondylosis or rheumatoid arthritis may be affected. A common first complaint, which should alert to the possibility of vertebral artery insufficiency in a patient with neck pain or injury, is of dizziness, and there may be light-headedness and nystagmus. These symptoms are not specific to vertebral artery insufficiency alone.

Examination

Always have the vulnerability and complexity of the neck in mind. Have a low threshold for precaution, consultation and referral. Begin with airway, breathing and circulation (ABC) and the patient's Glasgow Coma Scale (see Chapter 12).

Establish a history of injury. If the patient has been injured, assess the severity of the mechanism and ask about pain, movement and any neurological changes at any time since the injury until now. Apply the Canadian C-spine rules (see below). If you have concerns that the patient has suffered a significant injury to the spine defer examination: take precautions in line with your local policies to protect the spine and obtain a senior medical opinion.

The history of neck pain is often of an unexplained onset felt on waking. Ask about activities on the preceding day. Was an unusual amount of alcohol taken before bed? How are the patient's pillows arranged? Does the patient sleep in a prone position with the head rotated, a posture which is thought to stress the facet joints?

Has the patient been unwell in any way around the time of the onset of pain? Is there headache, vomiting, fever or rash? Be wary of any hint of cerebral or meningeal signs. Is there chest pain, breathlessness or palpitations? Is there a cough, sore throat or earache? Does the complaint involve any change in normal salivation, are there any new swellings around the neck?

Where is the pain? Does it radiate to the shoulder? Does it pass down the arm? Does it involve both arms or an arm and leg? How far does it radiate, and into which part of the arm? Is there dizziness or blackout; vision or hearing changes; any change in sensation or power; loss of coordination or symptoms in the lower part of the body, including changes in bladder and bowel function?

Ask about any diseases which might affect the spine or spinal cord, and any long-standing symptoms which might confuse examination. Certain diseases such as rheumatoid arthritis can predispose to a spontaneous dislocation in the spine. Take care even if there is no history of injury.

A posterior disc herniation will refer pain in a non-segmental way, as will injuries to facets and ligaments in the neck. Such pain may cause headache or scapular pain. Posterior/lateral herniations, compressing nerve roots, will cause dermatomal referral.

The pain of an injured neck may be quite severe; consider the need for analgesia and examine with care.

Look

Ask the patient to undress to expose the neck, both shoulders and the back. You will also make a neurological assessment of the arms (see below). A full examination of the legs is not always necessary but you should be satisfied that the patient is walking normally. A patient with a stiff neck will rotate the trunk from the waist in order to turn the head. The patient may have a torticollis, an abnormal posture of the head which is commonly a combination of rotation and side flexion. This is usually caused by muscle spasm; however, on occasion, more serious rotational deformities at the facets of the spine may occur. Assess spinal posture for kyphosis and scoliosis. Look at the posture of the shoulders. The medial border of each scapula should be about 5 cm from the spine. Note any asymmetry, wasting, spasm, bruising, redness or swelling.

If the patient has any infection signs examine the throat and the canals of the ears, and you may see raised lymph nodes around the neck.

The Canadian C-spine rules do not specify any aspect of posture which indicates higher or lower risk after a neck injury, although they do refer to the ability to sit upright in the emergency department (ED) (see below).

Feel

Palpation of the cervical spine is most easily accomplished if the patient lies face down on a trolley with the chin

pulled in. This flattens the hollow of the neck and makes the spine more prominent. Some examination trolleys have a space cut in the head rest which allows more flexion of the neck. At the top of the neck, in the midline, there is a palpable ridge, the nuchal line, which marks the junction between the skull and the midline of the posterior cervical spine. Below that, it is easy to feel the spinous process of C2. The next prominent landmarks on the way down are the large processes of C7 and T1. The intervening processes of the cervical spine can be felt, with more or less difficulty, depending on the patient, in the central hollow of the neck. Establish that each process is present, with no gaps or deviations. The transverse processes of the atlas are large and placed just below the mastoid processes of the skull. The others are felt by placing the fingers lateral to the central columns of muscle in the middle of the neck. Once again, the processes of C7 are particularly large.

Palpation of the muscles of the neck and shoulder may reveal tenderness and spasm. Feel for raised lymph nodes from below the mandible to the occipital area and ensure that there are no other swellings around the neck.

The Canadian C-spine rules require neck X-ray for patients with tenderness in the midline of the cervical spine.

Move

Assess movement with particular care when the neck has been injured. Remember that the purpose of resisted tests is to demonstrate muscle or motor nerve deficits, and the purpose of passive movements is to clarify whether a joint may be causing symptoms. In all cases of neck pain and injury, the patient should first demonstrate the active range of movement which feels safe and comfortable. A patient will not willingly move an unstable neck. Any passive testing should be very gentle. In cases where there has been an injury, and its nature and severity are not yet known, passive movement should be avoided completely. Be careful not to exacerbate the patient's symptoms or worsen the problem.

The active movements of the neck are shown in Figure 14.6.

Ask the patient to tell you if movements worsen or diminish the pain of which he or she is complaining. Ask if there are any other symptoms, including dizziness, faintness, weakness or tingling.

The Canadian C-spine rules require that a patient with an injured neck should be able to rotate the head at least 45 degrees in both directions.

Nerve tests in the arms

Reflex testing was shown in Chapter 12.

Exclude a loss of sensation or power to the arms in any patient who has suffered a neck injury. Awareness, with the eyes closed, of light touch, comparing one side with the other in each dermatome is usually an adequate assessment of sensation in an MIU. If any defect is found, further investigation is required. The area of any deficit should be mapped to allow a distinction between problems at the root and the peripheral system.

Power in the myotomes supplied by segments C4 to T1 can be assessed by resisted tests of the following movements:

- C4: shoulder elevation (upper trapezius): 'lift your shoulders, don't let me push them down'
- C5: shoulder abduction (deltoid): 'lift your arms away from your side, don't let me push them towards your body'
- C6: elbow flexion (biceps): 'bend your elbows to 90 degrees, palms up, don't let me straighten your arms'
- C7: elbow extension (triceps): 'keep your elbows bent, don't let me push your hands towards your shoulders'
- C8: thumb extension (extensor pollicis longus): 'turn your hands palm down and lift your thumbs towards the ceiling, don't let me push your thumbs downwards'
- T1: finger adduction (intrinsics): 'keep your hands palm down and spread your fingers. I am placing a sheet of paper between your fingers, don't let me pull it out'

Once again, any weakness will require further investigation, and a distinction should be made between a root lesion and a peripheral nerve problem. If weakness is present assess the full limb and map any deficits. The pattern of the problem will give indications of the probable source.

A patient who has a very painful, acute injury, such as a whiplash or an onset of severe neck pain, may not be able to comply with resisted tests, and any weakness or pain may be misleading. Such a patient may need an immediate senior medical opinion or further assessment at a later stage, perhaps by a physiotherapist.

Neck pain and injury

In the MIU there are two main categories of neck problems which we manage: minor trauma and pain with no history of injury.

The Canadian C-spine rules

The management of midline injuries is often based, at least in part, on clinical guidelines. The Canadian C-spine rules have widespread acceptance in the UK, in clinical practice and in imaging, for the management of neck injuries. Their acceptance by the Royal College of Radiologists is of particular importance because the guidelines classify patients, not by diagnosis, but according to their need for X-rays

Fig 14.6 Active neck movements. A, Flexion; B, extension; C, rotation (right and left); D, side flexion (right and left).

(and perhaps other forms of imaging) of the neck. They stream patients into three groups, exclusions, high risk and low risk. The criteria applied in these different categories are a mixture of elements of the patient's personal history and the history of the injury, and examination findings. Excluded patients are assessed according to individual risk factors. Elements of the history include a severe mechanism and the effect of the patient's injury on mobility and behaviour since the event. Examination findings include midline C-spine tenderness and neurological changes and they also select one neck movement, rotation, as a predictor of severity of injury.

The Canadian C-spine rules, exclusions:

- non-trauma cases
- GCS less than 15
- unstable vital signs
- age less than 16 years
- the presence of acute paralysis
- known vertebral disease
- previous C-spine surgery.

The Canadian C-spine rules, high-risk factors which require X-ray:

- age 65 years or over
- a dangerous mechanism of injury (for example, a fall from 3 feet or higher or five stairs; an axial load to the head, as in diving; high-speed road traffic accident (RTA) at above 60 mph, or with rollover or ejection from the vehicle; a quad bike or a bicycle crash)
- paraesthesia of the extremities.

The Canadian C-spine rules, low-risk factors which allow safe assessment of the range of movement:

- a simple rear-end RTA (excluding a push into oncoming traffic, an impact from a bus or large truck, a rollover, or being hit by a high-speed vehicle)
- the patient is in a sitting position in the ED
- the patient is ambulatory after the injury
- the patient has a delayed onset of neck pain
- there is an absence of midline C-spine tenderness
- the patient is able to actively rotate the neck 45 degrees to left and right.

The standard of certainty that you are asked to meet when you examine a patient with a neck injury is 'do I have sufficient concern about this patient, after my examination, to protect the spine and discuss the need for imaging with a senior clinician?'

> Box 14.5 **Whiplash examination**
>
> Examination of the patient should include:
>
> - LOOK: posture, torticollis, guarding
> - FEEL: palpation of the neck and surrounding structures to assess tenderness and spasm
> - MOVE: assessment of active range of movement only (avoiding any manipulation, including passive movement).
>
> Make a neurological assessment of power and sensation in the arms and reflexes (see Chapter 12). A patient who is walking and shows normal coordination and agility in leg movements does not require a full examination of the lower limb. Wardrope and English (1998) recommend that legs can be functionally assessed by asking the patient to stand on one leg, and then the other, with the eyes closed.

Neck injury: the rear-end shunt

The most common traumatic neck complaint which patients bring to an MIU is so-called whiplash, normally the result of a 'rear-end shunt' (Box 14.5). The Canadian C-spine rules classify a neck injury as a result of a low-speed, uncomplicated, rear-end RTA as low risk. The term 'whiplash' is controversial, but that is only of interest here to the extent that a standard pattern of injury should not be assumed in any given case, even though the description of how the injury happened may be rather similar from one patient to another. The patient has been involved in a car crash and will probably be distressed and unclear about the exact mechanism of injury.

Factors such as the position of the head at the moment of impact are important in assessing the risk of fractures, subluxations and ligament injuries. Other aspects include the exact position of the patient in the car, the direction and speed of both vehicles, the sizes and types of the vehicles, the points where the vehicles made contact and the movement of the patient's car afterwards. Was the patient wearing a seatbelt? Was there a headrest? Did an air bag deploy? Which way was the patient looking at the time of collision and was the impact anticipated or completely unexpected? Did the patient's head hit anything? Was there broken glass?

The patient's signs and symptoms should be established from the time of the injury to the time of the examination: remember that the Canadian C-spine rules attach significance to a delayed onset of pain. If the symptoms have resolved, when did that happen? Was the patient knocked out? Is the patient suffering from headache, amnesia, discharge from nose or ears, neck pain, blackouts, visual disturbances, nausea and vomiting, hearing disturbances, dizziness, coordination problems or weakness or loss of sensation in the limbs? Does the patient have any wounds, bruises or swelling? Are there injuries to clavicle or chest caused by the seat belt?

Observe the patient's posture and demeanour. Patients who have just emerged from a car crash may look pale and sweaty or they may be distressed and tearful because they are reacting to the incident rather than because of injury. Take a history and make a careful assessment before accepting that that is the case.

A common account is of a patient stopping the car for a traffic light, or making an emergency stop, and a vehicle behind driving into the rear. The patient's head is thrown backwards and forwards, and neck pain follows some minutes or hours later.

Corrigan and Maitland (1998) describe the mechanism:

1. The impact drives the patient's body forward, throwing the head back and hyperextending the neck.
2. The muscles at the front of the neck reflexively contract, and the neck is flexed.
3. The head and neck decelerate.

The most traumatic aspect of this event is the hyperextension, because the chin will hit the chest before any significant hyperflexion of the neck can occur. Hyperextension can damage muscles, ligaments (especially the anterior longitudinal ligament), the discs (by compression at the back of the disc, overstretching at the front, or tearing of the whole disc from the endplate) and the zygapophyseal joints, which may suffer fractures.

Treatment

If you have access to a physiotherapist, establish guidelines for the referral of patients with this type of injury. It is likely that the physiotherapist will favour early and active intervention for some patients, but that the larger number will be expected to be referred through their general practitioner (GP) if the injury has not settled.

A neck injury of this kind is managed as a grade 1 sprain unless there are criteria for an immediate referral to a physiotherapist such as a very restricted or painful neck. The management is also influenced by the tendency to spasm which is a feature of neck injuries. It is useful to

describe a simple regimen for symptom relief and mobilisation in an advice leaflet:

- Soft collars are avoided because they encourage stiffness and muscle weakness. If there is spasm, or if the muscles are painful or tired, the patient can relieve this by reclining so that the head is supported. The hollow of the neck can be further supported with a rolled-up towel. Moderate use of heat is also helpful for muscle spasm, but ice is preferable for the first day or two.
- Gentle movements in the same pattern as for neck examination, within the limits of pain, will help to prevent unnecessary stiffness.
- In bed, supporting the head and neck in a neutral position, using rolled-up towels or the like to support the hollow in the back of the neck when lying flat, and higher pillows when lying on the side, will maintain comfort and reduce the risk of waking with a torticollis.
- The pain may worsen over the first few days. Use paracetamol as a first line of treatment if the patient can tolerate it. Ibuprofen, for patients who can tolerate it, has analgesic and anti-inflammatory properties. Advise the patient to see a GP if pain relief is a problem.
- Neck pain can persist for weeks. The patient should avoid excessive levels of activity when movement is still painful or if there is spasm. If pain persists in this way consult the GP about other options such as physiotherapy.

Nerve root pain (cervical radiculopathy)

Pressure on or irritation of nerves as they emerge from between two neighbouring vertebrae, usually caused by a herniation of nucleus pulposus gel from the adjacent intervertebral disc, can cause pressure on the dura mater which surrounds the nerve and pain which is referred to the dermatome which sends sensory fibres to that level of the spine. If the pressure is sufficiently severe, the nerve itself can suffer a deficit, a loss of function which the patient will experience as reduced sensation and weakness in the pathway of that nerve alone (a phenomenon known as **focal neurology**). There may also be a suppression of the reflexes which the patient is unlikely to notice, but which you will find on examination.

The patient will commonly present with a complaint of pain in the shoulder or arm. The pain will be exacerbated or relieved by neck movements.

Examine the patient carefully as above, exclude bilateral or lower limb involvement and map the extent of any neurological deficit.

Initial treatment is rest and analgesia. If the problem does not settle quickly the patient's GP may consider a referral to physiotherapy and, occasionally, patients require imaging and surgical referral.

Torticollis or wry neck

Torticollis is a clinical appearance rather than a diagnosis. The neck is twisted, both tilted and rotated, muscle spasm is present and the patient cannot straighten the head. Torticollis is probably a spasm response to a small, unnoticed injury in the neck. However, it is unusual among minor injury presentations in its history: we usually demand a history of injury in an MIU but the reverse occurs with torticollis. The usual story is that the patient goes to bed feeling fine and wakes with a twisted neck. A story of trauma in a patient with torticollis will trigger spinal precautions and a senior consultation. Other problems besides a small injury, such as infection, can trigger a torticollis and you must assess the patient carefully. The cause of a torticollis usually remains obscure and it will not be pursued if the problem resolves quickly as it usually does. It is most common in young adult women. There are usually no neurological deficits.

Be careful to consider the patient's viewpoint, literally, with torticollis. The inability to straighten the head affects balance, sight and swallowing and it can create a panic in someone who has no experience of the problem. It is often helpful when you meet the patient to ask him or her to lie down flat on a trolley. This tends to relieve the spasm and allow the neck to straighten. Do not force the neck; let it settle over a few minutes with minimal handling. The knowledge that the problem is reversible and that rest and heat are useful antidotes to muscle spasm will be supportive. Advise the patient to rest for a day or two, to use rolled-up towels in the hollow of the back of the neck when sitting and to align pillows to support the head in a neutral position in bed. Simple analgesia will also be helpful for the underlying cause of the problem.

Neck injuries in children

Children can suffer unstable ligament injuries and fractures to the spine. The pattern of injury is similar to that of adults when the child is near to full growth. In younger children, the difference in physical proportion, larger heads and relatively short, weak necks, means that injury occurs at the upper part of the neck, at C1 and 2, with fractures often of the odontoid peg. A severe mechanism, especially when the child has marked pain, stiffness and spasm should be taken seriously. See Box 14.6 on clearing a child's neck.

The flexibility of a child's spine may permit a serious injury to the spinal cord with no fracture, a phenomenon named **SCIWORA** (**spinal cord injury without radiological abnormality**). The mechanism will usually be severe: a road traffic accident or a high fall. If a child has suffered a mechanism which could produce neck injury, such as a significant head, trunk or spine injury, leg fractures, or if

Box 14.6 Clearing the child's neck

- Alert asymptomatic children with normal examination can be cleared without X-ray if the mechanism has been minor.
- Children who have suffered a severe mechanism of injury, with or without C-spine signs, require spinal precautions, senior discussion and imaging.

Box 14.7 Spinal cord injury without radiological abnormality – SCIWORA

- SCIWORA happens to children because there is less bone and more ligament laxity in the spine. The spine can sublux, damage cord, and reduce to a normal position.
- The signs may not be present on examination, and a history of previous signs is important.
- Usually patient is <8 years. If in doubt, keep immobilised. May need MRI scan.
- Older children are nearer to the adult pattern of injury with lower C-spine presentations.

the patient has neck pain, radiating pain or a history of neurological symptoms since the injury, do not depend upon a normal examination: protect the spine and consult your paediatric emergency service (Box 14.7).

Children also present with torticollis. A local infection (such as tonsillitis) should be ruled out. Atlanto-axial rotatory fixation, a slippage between C1 and C2, is a condition which can occasionally occur in children, possibly after a minor trauma. The patient will present with torticollis, with a fixed rotation and tilting of the head. There is usually no neurological deficit. The patient requires referral for imaging and treatment (Box 14.8).

Box 14.8 Torticollis in children

- The back of the head tilts towards the affected side and the chin rotates to the other side, caused by contracted sternocleidomastoid on affected side caused by a minor injury to the head or shoulder. Treat symptoms.
- Inflammatory disorders (retropharyngeal abscess and mastoiditis are serious but uncommon) can cause torticollis. Treat underlying cause.
- Atlanto-axial rotatory fixation is the atlas (C1) locking in a turned position in relation to axis (C2). X-rays are required. May need traction.

Box 14.9 Lumbar spine statistics

- Capsular pattern: equal restriction of side flexion and rotation, and a lesser degree of loss of extension.
- Joint positions: close packed is full extension, when the facets meet; loose packed is halfway between flexion and extension.
- Flexion up to 60°; endfeel is firm, ligament and facet joint capsules.
- Extension up to 35°; endfeel firm; the posterior bony surfaces meet and the anterior disc, ligaments and muscles are stretched.
- Rotation up to 18°; endfeel firm; movement is ended by ligaments and articular processes.
- Side flexion up to 20°; endfeel is firm, restricted by the ribs (the facet joints coming together) and stretching of the joint capsules.

THE LOWER BACK

Introduction

Pain in the lower back is rather like the common cold, universal but poorly understood and a source of frustration and misunderstanding between health professionals and patients. This section focuses on the distinctions between emergencies where back pain is a symptom, serious and less-serious neurological presentations, and so-called non-specific or mechanical back pain.

You will usually refer patients who present with abdominal pain to a doctor. Genuine minor injury presentations with abdominal pain as a main symptom are unusual.

Anatomy of the lumbar spine

The general structure of vertebrae, the arrangement of spinal ligaments and the way in which spinal nerves emerge from the vertebral column were discussed above. Articulation between the lumbar vertebrae occurs in the same manner as in the higher vertebrae:

- between intervertebral discs and vertebral bodies
- between two facet joints on the inferior aspect of the upper vertebra, and two facet joints on the superior aspect of the one below.

There are five lumbar vertebrae (see Fig. 14.1); these are chiefly distinguished from the higher vertebrae by their adaptation for weight bearing. They are large, and their facet joints are directed so that they limit rotation at the lumbar spine (most of the rotation which can be achieved in the trunk occurs in the thoracic spine) for the sake of stability (Box 14.9).

The spinal cord is shorter than the vertebral canal and ends at the level of the first lumbar vertebra. From there, the

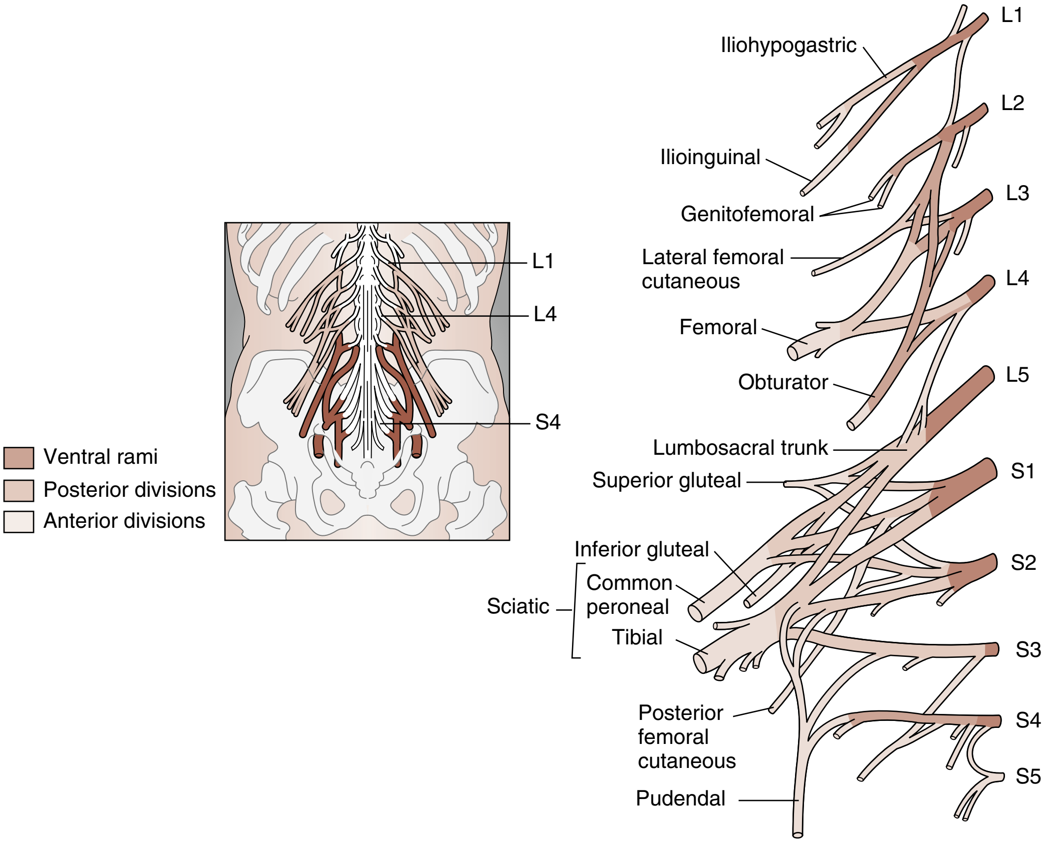

Fig 14.7 The lumbosacral plexus.

nerves, which pass out through the intervertebral foramina of the various lumbar vertebrae, pass down the canal to their exit points as a collection of long strands, called the **cauda equina** (horse's tail).

The ventral nerves from L1 to S4 supply the leg. As at the neck, these nerves form networks which permit the exchange of fibres between nerves emerging from the spinal cord and forming peripheral nerves in the limb. There are two networks which are relevant here: the **lumbar plexus** and the **sacral plexus** (Fig. 14.7 and Box 14.10).

The lumbar vertebrae rest upon, and articulate at L5, with the superior surface of the **sacrum**, a wedge of bone which links the two posterior segments of the pelvis at the **sacroiliac joints**. The sacrum is the superficial bony surface which can be felt in the midline of the buttocks, just above the cleft. It is considered as a single unit, but it actually comprises five fused vertebrae. It combines three roles. It is the base upon which the vertebral column is stacked, it is the link between the spine and the pelvis, and it is one of the unifying elements between the two halves of the pelvic girdle.

The vertebral canal continues down into the sacrum as the **sacral canal**. On the front surface of the sacrum, there are four **transverse lines**, which mark the fusion of the sacral vertebrae; there are holes at each end of these ridges, **sacral foramina**, which allow the passage of nerves and blood vessels. On the dorsal, convex surface of the sacrum, there is a raised, vertical ridge in the midline; this is the vestige of the spinous processes and is called the **median sacral crest**. The ridge is incomplete. The fourth and fifth spinous processes are absent, and, at that part of the midline, there is a small opening, the **sacral hiatus**, which gives access to the sacral canal at its inferior end.

The sacroiliac joints are synovial joints, only slightly moveable, between the sacrum on each side and the articular surfaces of the ilium on each side. These joints close the ring of the pelvis at the back. They are reinforced by interosseous ligaments at the back and front. The posterior ligaments may be torn by injury during the movement of bending forward at the waist.

The sacrum has a small bony tail, the **coccyx**, made of four or five more vertebrae, also fused. The coccyx has no

Box 14.10 The lumbar and sacral plexus

- The lumbar plexus and the sacral plexus overlap a good deal and have a shared lumbosacral trunk.
- They mainly supply the legs but some fibres pass to the abdomen, pelvis and buttock.
- The lumbar plexus arises from L1–L4. It lies in the psoas major muscle, a deep hip flexor. Its main area of action is in the anterior thigh. Its largest terminal branch is the femoral nerve.
- The femoral nerve supplies the quadriceps and gives sensation to the front of the thigh and the inner leg from knee to foot.
- The **obturator** nerve passes through the **obturator foramen** of the pelvis to the medial thigh and supplies the **adductor** group of muscles.
- The **sacral plexus** arises from L4–S4. Some fibres from the lumbar plexus mix with the sacral through the **lumbosacral trunk** at L5.
- The sacral plexus serves the pelvis and perineum as well as the buttock and leg.
- The largest branch of the sacral plexus is the **sciatic nerve**, the thickest and longest nerve in the body. It serves the whole leg except the front and inner thigh.
- The sciatic nerve is actually two nerves (the **tibial** and the **common fibula**r or **peroneal**) in one sheath; it leaves the pelvis at the greater sciatic notch and passes down the buttock.
- It gives motor fibres to the **hamstrings** and **adductor magnus.** Above the knee its divisions separate.
- The **tibial nerve** supplies the calf and sole of the foot. One tibial branch, the **sural nerve**, supplies the skin of the posterolateral lower leg. Another tibial branch, the **plantar nerves**, serves most of the foot.
- The common fibular or peroneal nerve descends and wraps around the head of the fibula.
- It divides into superficial and deep branches which supply the knee joint, the skin of the lateral calf and dorsal foot and the extensor muscles of the anterolateral lower leg.
- Other branches of the sacral plexus are the **superior** and **inferior gluteal nerves** which supply **gluteal** and **tensor fasciae latae** muscles and the **pudendal nerve** which supplies the perineum, and has control of urine and erectile function.

distinct function. It is palpable as a rough, superficial bony surface, just above the anus.

The patient with back pain

Back pain, at first sight, is a musculoskeletal condition which can be managed in the same way as other problems of that kind. However, back pain is a problem of serious and increasing significance for sufferers, their families and society at large. In the UK, back pain causes more long-term absence from work than any other problem. Many people who suffer from chronic back pain give up their work for good, which is a drain on the health and social security systems and a cause of misery for the individuals and their families.

The assessment of a painful back can be divided into three stages:

1. Exclude a 'red flag' emergency.
2. Exclude illness rather than injury.
3. Exclude a neurological rather than mechanical cause for the pain.

It is important that two emergencies are excluded in patients with back pain: lumbar disc prolapse, which threatens the nerve supply to bladder and bowel (**cauda equina syndrome**), and an abdominal aortic aneurysm. There is a long list of other serious problems which can present with low back pain.

The patient with a disc prolapse compressing the spinal cord at L1, or the cauda equina in the lower lumbar region, may suffer irreversible damage, and magnetic resonance imaging (MRI) is the most useful investigation to exclude that diagnosis. The patient may complain of bilateral leg pain (most commonly radiating down the backs of the thighs) and loss of coordination with paraesthesia and weakness in the legs, perianal paraesthesia (in the so-called **saddle area**), a loss of tone of the rectal sphincter, and, possibly, a loss of bowel control or retention of urine (with overflow as the problem progresses). The patient may need emergency surgery (an assessment that would be made by a neurosurgical or an orthopaedic specialist, depending on local arrangements).

A patient with an abdominal aortic aneurysm may present with back pain, which will not be in the pattern of musculoskeletal injury. It will be constant and probably worsening, not improved by a change in position, and no better at night. It may radiate into the groin and thigh. There may be a swelling in the abdomen, the classic **pulsatile mass**. This condition is most common in men in later middle age. If this diagnosis is suspected, the patient should be referred as an emergency. The aneurysm may rupture at any time, even if the patient seems well at the moment. Always include an assessment of the patient's abdomen in your examination of a painful back.

Children with a history of back pain which is not clearly connected to an injury require a senior or specialist assessment, depending on your local pathways.

If a patient has suffered a violent mechanism of injury, such as a road traffic accident or a fall from a height, he will not be managed as a minor injury. The patient may have rupture of internal organs, with heavy bleeding or spinal, pelvic or hip injuries. Assess (and constantly reassess)

in terms of resuscitation and ABC; the patient may require spinal board immobilisation and emergency ambulance transfer.

There are other medical problems, including neoplasm, osteomyelitis, osteoarthritis and infections of the genito-urinary and gastric tracts, which may cause the patient to present with back pain. There will be no history of injury, the pattern of pain will not be musculoskeletal, and there may be other systemic signs, such as a raised temperature. The patient may have a history of previous cancer, of recent weight loss or may feel generally unwell. The older patient, above 55 years, should be considered as at a higher risk.

In any case where there is doubt, refer the patient.

Common patterns of back pain

For all that the problem is common and increasing, the causes of, and predisposing factors for, back pain are not well understood. The guidelines which are current for the treatment of patients with back pain do not concentrate on precise diagnosis. The objective is to recognise patterns of presentation, and patterns of outcome, and to make a correct assessment of the *type* of problem, so that the patient is guided along the path which appears, from other patients' experience, to offer the best hope of recovery.

The urgent and serious conditions have been discussed above. Among the less serious, more common presentations, there are two large categories:

- The main symptom is pain radiating down one leg.
- The main symptom is pain in the lower back with no significant radiation to the leg.

The first of these is less common than the second (less than 5% of all patients with back pain according to Burn, 2000). The pain which is referred down the leg because of pressure on a nerve root will follow a dermatomal pattern and will be triggered or increased by a specific test for stretching the nerve (the **sciatic** or **femoral** stretch [see below and Fig. 14.11 and Box 14.11]). Note that nerve root pain from the upper lumbar spine will refer pain to the front of the thigh which may not pass below the knee. The dermatomes for the lower part of the lumbar spine and the sacrum, at the back of the leg, pass all the way down to the foot and 'sciatica', the more common type of nerve root pain in the back, will be felt in the whole leg.

The second major category of back pain sufferers includes patients who may have pain which radiates to the upper part of the leg (not below the thigh), in a non-dermatomal pattern; this pain does not have a neurological origin. This group, the larger by far, is suffering from **non-specific** or **mechanical** back pain. The pain is triggered by lifting or bending, and there may be either a sudden severe pain or a gradual onset. If the patient experiences muscle spasm at the time of the injury, the back may 'lock' in lumbar flexion.

Box 14.11 Sciatic stretch test

- A passive straight leg raised above 75° will cause pain and paraesthesia in the leg if there is a disc protrusion at L4 to S1.
- To ensure that pain is caused by the sciatic nerve, and not hamstring stretch, lower the leg slightly until pain stops, then dorsiflex the foot.
- The test is positive if the pain returns.

The pain may be felt on one or both sides of the lower back. There may be radiation of pain to the upper part of the back of the leg but not to the foot. The pain will have a musculoskeletal pattern, being aggravated by physical activity and relieved by rest, especially by lying down.

Examination

History

'Non-specific back pain' is a broad diagnosis, partly arrived at by a process of elimination. The history plays a large part. The patient's age, gender, occupation and general lifestyle will have great bearing on the possible diagnoses and the priorities of treatment.

Treat young patients and those over 55 years of age with care. These groups are at higher risk of non-musculoskeletal causes for their back pain.

Establish a mechanism of injury. There may not have been a severe force, but the patient will probably recall a recent exertion or may say that the pain began while bending forward. In most cases, there will be some pain at the moment of injury, even if it does not become troublesome until later.

Assess the pattern of pain, its relationship to movement, relieving and aggravating factors, the effects of the pain on sleep, whether it is worse in the morning. Coughing tends to aggravate the pain caused by a lumbar disc prolapse.

Ask about severity of the pain, and whether or not it developed suddenly. Ask where the pain is felt, and whether there is radiation of the pain. If there is pain in the leg, ask if it is more severe than the back pain, which tends to be the case with sciatic pain, and map its pathway on the leg. Ask if there is numbness or tingling. Is the patient aware of limping?

Ask if the patient feels well, apart from the back pain. Ask about any other symptoms: chest pain, abdominal pain, bilateral leg pain, any weakness or paraesthesia, coordination problems, change in bowel or bladder habit.

Obtain a full medical history, including medications and allergies; ask if the patient is taking steroids. Has the patient any history of arthritic disease? Has the patient had any surgery?

Consider medical referral if there are any atypical features, if the patient is describing severe symptoms, or if the history suggests an illness rather than an injury.

Physical examination

Look

The patient's ability to stand up and sit, the pattern of walking, the posture and the ability to perform simple tasks, such as tying shoelaces, will give an impression of the pattern of disability and the severity of symptoms. Is the patient limping? The pain and the fatigue which simple back pain causes can be considerable.

Ask the patient to undress and observe the back and the legs. The patient may have a scoliosis, a lateral curvature of the spine. Scoliosis may exist for different reasons, such as the need to compensate for the angled pelvis which results from having unequal leg lengths, but it may be an acute response, an attempt to relieve the pressure on a compressed nerve root. Look at the pelvis. Is it tilted? You may assess this by checking the levels of the posterior superior iliac spines.

It may be possible to see, on one side of the lumbar spine, the contracted mass of erector muscles of the spine in spasm.

Feel

The lumbar spine is best palpated with the patient prone on a couch. The spinous processes are easy to feel, but the transverse processes may be fairly deep in the erector muscle bulk. Muscle which is in spasm may be both visible and palpable.

It is a sound precaution, especially with older patients, to palpate the abdomen with the patient supine. Feel for tenderness or pulsation in the suprapubic area. Check the femoral pulses.

Move

Active movement in the back is assessed as:

- the range of movement
- the rhythm of movement
- whether or not there is pain on movement.

Test the lumbar spine in flexion, extension and rotation (see Figs 14.8–14.10). Perform the sciatic nerve stretch test (see Fig. 14.11 and Box 14.11). If there is pain in the front of the thigh, the femoral stretch test may be required. The sciatic stretch test, with its passive straight-leg raise, stresses the nerves and their roots from L4 to S1, which are the most likely to suffer the effects of a disc prolapse.

Assess sensation in the legs in all dermatomes and map any deficit. Motor power in the legs can be assessed, using resisted tests for the following muscles:

- L2: hip flexion (iliopsoas): 'lift and bend your knee and hold your foot above the trolley, don't let me push your thigh down'

Fig 14.8 Flexion at the waist.

Fig 14.9 Extension at the waist.

- L3: knee extension (quadriceps): lift your straight leg, don't let me make your knee bend
- L4: ankle dorsiflexion and inversion (tibialis anterior): 'pull your foot up towards you at the ankle, don't let me push it down towards the end of the trolley'

Fig 14.10 Side flexion at the waist.

Fig 14.11 The sciatic nerve stretch test.

- L5: big toe extension: 'lift your big toe up towards you, don't let me push it down towards the end of the trolley'
- S1: ankle plantar flexion (gastrocnemius): point your foot down towards the end of the trolley, don't let me push it up towards you'
- S2: toe flexion (flexors digitorum and hallucis longus): 'curl up your toes, don't let me straighten them'.

To perform the sciatic stretch test: the patient lies supine and you stand at the foot of the trolley. Lift the patient's foot by the heel so that the straight leg is passively flexed at the hip. Keep lifting and ask the patient to tell you if pain is felt. The movement ends when the hamstrings become tight unless the sciatic nerve is symptomatic, in which case the patient will announce pain travelling down the back of the leg. Lower the leg until the pain settles. In that position, passively dorsiflex the ankle. If the pain returns, the test is positive for a sciatic nerve root impingement (nerve roots L5–S2).

To perform the femoral nerve stretch: the patient lies prone on the trolley and you stand to the side that you are testing. Passively flex the knee, bringing the heel towards the buttock, as far as is comfortable for the patient: if this causes pain in the anterior thigh the test is positive (L1–L4). If there is no pain, add a further stretch by passively extending the hip joint with the knee still in flexion.

Test reflexes at the patella and Achilles tendons.

In any case where there is doubt about cauda equina syndrome the patient will require a per rectum examination to establish that the anal sphincter has good tone. Ask the patient to squeeze the examiner's finger by clenching the buttocks.

Treatment

Refer the patient to a GP if he needs more help with analgesia than you can give. Non-specific back pain can be severe. The usual first line of pain relief is paracetamol. Ibuprofen or another non-steroidal anti-inflammatory drug may be added if simple analgesia is insufficient. There is a role for muscle-relaxant medication but a first line of management for spasm is rest and heat and you are unlikely to go beyond this in the MIU (see below).

Patients who have sciatic pain should be referred to GPs as long as they have no evidence of weakness or loss of sensation and reflexes are normal. (If focal neurology is present discuss this with a senior ED doctor.) The problem may not be quick to settle, extra pain relief may be needed and, in a few cases, the patient may need orthopaedic treatment.

Current thinking on the treatment of non-specific back pain emphasises two priorities: remain mobile and stay at work. The GP is seen as the lynchpin of management of the condition. Rest should be kept to a minimum, except in the case where the pain arises from nerve root problems. Physiotherapists, chiropractors and other specialists in manipulation should be involved if the problem does not settle within a few days. The management of patients with sciatic pain should differ in the length of time resting, but in other ways, the principles are the same as for non-specific back pain. The patient should move on to a programme of active exercise as soon as possible and should stay at work if possible.

There is a large role for health promotion for patients with back pain. The condition can be recurrent, disabling and depressing. Subjects such as safe lifting and the value of exercise to prevent injuries and help recovery are very important.

Muscle spasm causes troubling symptoms for sufferers from back pain. On occasion drugs such as diazepam are prescribed if the symptoms are not settling. This would not be the first resort. Muscles which are in spasm are in a protracted state of contraction as a protective reflex to guard the injury. The muscles cannot perfuse themselves adequately in this condition, and the patient cannot move properly. Two simple tactics can help. The muscles will relax if they are rested from their normal activity. For a patient with back pain this means lying down. The use of heat applied locally increases blood flow to the area and encourages the spasm to relax and perfuse itself. Heat should be used with care: the situation will not be improved if the skin is burned.

The priority of management is mobilisation but do not let this blind you to any immediate distress that the patient is suffering. The patient sometimes comes to hospital in severe discomfort, walking in an awkward way and unable to sit, stand or lie. If the patient is hanging on to the back of a chair to stay upright the word 'mobilise' will sound callous. The first stage of care is to give analgesia and settle the spasm. Advise on an incremental programme of mobilisation which will accommodate the tendency to spasm. If the back tightens up, the patient should revert to heat and support.

A summary

For patients with back pain:

- Rule out red flags, especially cauda equina and abdominal aortic aneurism.
- Treat children and over 55s as high risk.
- Ask yourself 'is the patient ill or injured?'
- Ask yourself 'if injured, is the problem musculoskeletal or spinal in origin?'
- Ask yourself 'if spinal, is the problem confined to nerve root or is there focal neurology?'
- If any neurology is present review the question of cauda equina. In any case, discuss the patient with a senior doctor before discharge.

Chapter | 15 |

The chest

CONTENTS

INTRODUCTION

This section deals with injured ribs. The only type of chest presentation that can be accepted as minor is a blunt injury to the ribs and only then if the mechanism is of a single, moderate impact. Patients with penetrating injuries, crush, multiple injuries and chest pain with no history of injury do not qualify. Patients with blunt rib injuries may also be shown to have a severe injury and it is part of the routine assessment of every presentation to rule out the main concerns.

Rib injuries are midline injuries. The lack of interest in a musculoskeletal diagnosis, the focus on the major organs, the systemic assessment of the patient and the examination of different body systems are all typical of this type of presentation. Rib injuries are unorthodox midline presentations only in lacking guidelines for their management. However, the Royal College of Radiologists discusses rib injuries in its guidelines on making the best use of a department of clinical radiology: it vetoes routine chest X-rays to diagnose fractured ribs on the grounds that they will not change the management of the injury unless there is suspicion of a pneumothorax or a chest infection. It also recommends other imaging options for injuries to the sternum, heart, major blood vessels, spine, liver, spleen and kidneys. Whether or not the patient requires imaging of this kind is the central question around which you will build your examination.

Children and rib injuries

Young children are more prone to injure major organs in the chest and abdomen than adults who suffer a similar injury. There are several reasons for this:

- Children have springy ribs compared to adults, less prone to fracture but also less able to protect the underlying organs. There is also less guidance on the severity of the underlying damage from the external signs: if an adult has multiple rib fractures or a fracture in the first or second ribs we will be alert for deeper injuries. The same degree of force may not break the child's ribs but it is likely that the energy transmitted to the interior of the thorax and the upper abdomen will be even greater.
- A child has a smaller body and less soft tissue to protect the abdominal organs. It is easier for a transmitted force to include several organs or to attack both chest and abdomen.
- The organs in the upper abdomen, the liver and spleen, are less well covered by the ribs in young children than in later years.

It is also a specific concern that children who have had glandular fever may suffer enlargement of the spleen: they are vulnerable to rupture of that organ. An injury to the chest or abdomen, especially in the month or so after the onset of the illness, is dangerous and any child who is in that situation should be referred to a paediatric specialist.

Elderly patients and rib injuries

As with young patients, the elderly have less capacity to resist trauma to the ribs, both in their thinning bones and in their wasting muscles, and are more likely to suffer fractures than younger adults. As with every other health issue that affects the elderly, the situation can quickly whip up into a perfect storm. Physical and cognitive decline leads to an accident, or a collapse, the accident allows established morbidities and opportunistic predators such as

pneumonia to assert themselves and prolonged pain and disability reduce resistance in the patient.

It is important in the first stage of contact to make an accurate assessment of the injury. It is more important than for younger people to decide if fractures are present because lung trauma and vulnerability to chest infection are larger factors. It is also important to establish whether a collapse has caused the injury and to make an appropriate referral for assessment.

It is important to be aware that the morbidity for elderly patients after rib injury is high, with death twice as likely from complications such as pneumonia than for younger adults. A regimen of chest care (see below) is vital. The cornerstone of the campaign is analgesia. Pain will lead to immobility and fatigue and decline will inevitably follow.

It is also important for your discharge plan to include the social and primary care support that is available: the threshold for admission to hospital will come down if the patient is unsupported at home. You will educate relatives on the need for the timing of analgesia to assist deep breathing and coughing sessions and sleep. A well-written, accessible advice sheet will be invaluable.

ANATOMY

The ribcage is a box-like, bony and cartilaginous, protective structure for vital organs: heart, lungs, liver and spleen and the large vessels of the circulation. In cases of injury to the lower ribs, damage to the kidneys is possible. Like every musculoskeletal structure, it makes concessions to contradictory demands. It cannot be sealed off because its organs serve every part of the body. It cannot be completely rigid because it moves to allow breathing and contributes to the overall mobility of the trunk.

Spine

The anatomy of the spine has been discussed in Chapter 14.

At the back, in the midline of the trunk, lies the thoracic spine (Fig. 15.1). There are 12 pairs of ribs, and each one of them articulates with one or two of the 12 **thoracic vertebrae**. The thoracic vertebrae do not have the transverse foramina of the cervical vertebrae, which carry the vertebral arteries upwards from neck to brain, but they do have facets on the sides of their bodies for articulation with the ribs. The upper thoracic vertebrae are similar in size and appearance to those in the cervical area. They become bigger as they descend, making the transition to the lumbar region, where the vertebrae are large, adapted for bearing the weight of the entire upper body. The spinous processes of the thoracic vertebrae are long and angled downwards.

Sternum

The sternum is the breastbone (Fig. 15.2), a long, irregular plate of superficial bone which lies between the twin mounds of the chest in the frontal midline. It is made up of three bones, one above the other, linked by cartilage joints. The upper one is the **manubrium** (meaning, handle). Marieb (1995) describes it, very appropriately, as looking like the knot in a necktie. At the superior end of the manubrium is a hollow, plainly visible between the medial ends of the clavicles, the **sternal notch**, and there are two **clavicular notches**, divided by the sternal notch, for the clavicular articulations. At the widest part of the 'knot' are two articular facets for the **costal cartilages** (costa means rib) of the first ribs. The **body**, the longest part of the sternum, is joined to the lower end of the manubrium at the **sternal angle**. This is a hinge joint and forms a prominent, horizontal ridge on the upper sternum at the level of the insertion of the costal cartilage of the second rib. It is a useful landmark during examination. The body offers insertion points on each side for the second to seventh costal cartilages. The second costal articulations, at the sternal angle, are shared with the manubrium. The third to sixth articulations are notches along the sides of the body. The seventh is at the level of the **xiphisternal joint**, and the xiphoid process shares the articulations with the body. The **xiphoid** (meaning, sword) is a small process at the inferior end of the body which offers attachment to the diaphragm and to muscles of the abdomen.

Ribs

The ribs are bones which ossify from cartilage. They are long, flattened, curving and twisting, having approximately a C-shape when seen from above. They are angled downwards as they curve from the thoracic spine at the back to the sternum at the front. They are variable in appearance, depending on their position in the thorax. There are 12 pairs of ribs, and they form a cage, open at the top and bottom (the **thoracic inlet** and **outlet**), with horizontal bars which constantly separate and come together to allow the lungs to expand and to deflate. The **intercostal spaces** between ribs contain muscles, nerves and blood vessels. The intercostal muscles act to widen the spaces between ribs during inspiration. The intercostal blood vessels may cause a haemothorax if they are injured. A residue of hyaline cartilage is found at the front end of each rib. This costal cartilage links the first seven ribs to the sternum. The costal cartilage of ribs 8 to 10 merge with that of the seventh rib and are, therefore, only indirectly connected to the sternum. The cartilage of ribs 11 and 12 (short ribs, sometimes called **floating ribs**) merges with the muscles of the abdomen at the front and they have no sternal connection. Each rib has, at the back, a **head** with two facets for articulation

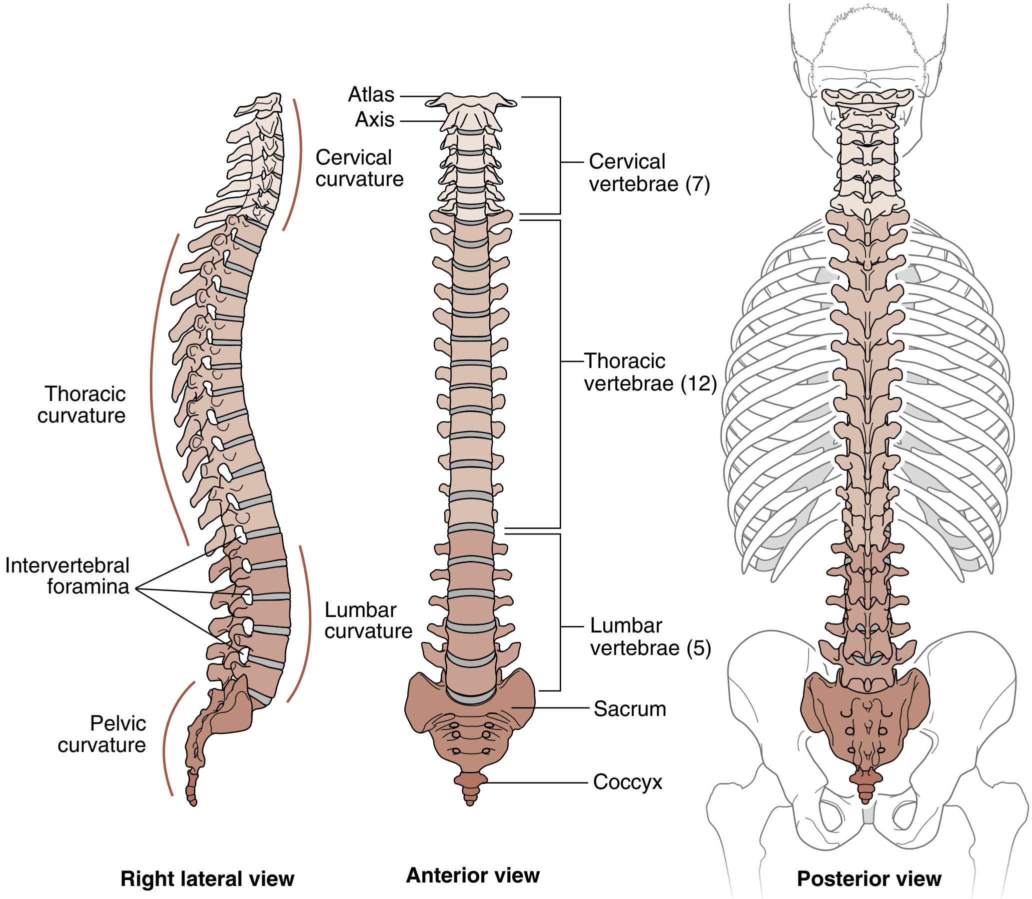

Fig 15.1 The vertebral column.

with the lateral bodies of two neighbouring thoracic vertebrae, the rib's own vertebra and the one directly above.

The costal cartilage is covered with **perichondrium**, a membrane which blends with the periosteum of the ribs. The cartilage can be torn by injury without separation of this outer layer; consequently, there may be a deceptive appearance of integrity in a damaged structure.

INJURIES

The usual mechanisms for blunt rib injuries are sport in the young and falls, especially in the intoxicated and the elderly. Typical tales are of a blow by an elbow or knee to the chest, a fall with the patient's own elbow trapped against the ribs or a fall in a bath with the arm lifted so that the chest strikes the edge of the bath or basin. Patients who have had a chest infection and have been coughing remorselessly will sometimes experience a sudden cracking or tearing in the chest; they will then have the typical pain of those with injured ribs. Assault with blunt objects is another source of rib injury, and you must exclude injury to the thoracic spine, the scapulae, the sternum and the clavicles (as well as other injuries).

The patient will localise a painful spot, which will be very tender. There may be no bruising. The patient may describe abnormal grating or clicking on breathing, and you may feel crepitus when the spot is touched. Crepitus can indicate a mobile fracture or a tear at the junction between the rib and its cartilage. There may also be surgical emphysema, a palpable crackling in the soft tissue caused by air from a pneumothorax.

Pain is a considerable feature of rib injuries. It is not usually present at rest but is triggered by deep breathing and coughing, and by certain movements. Sleep may be disturbed because it is hard to lie comfortably, and because movement in the bed hurts. Pain tends to worsen, or become more tiring, on successive days for a week or so,

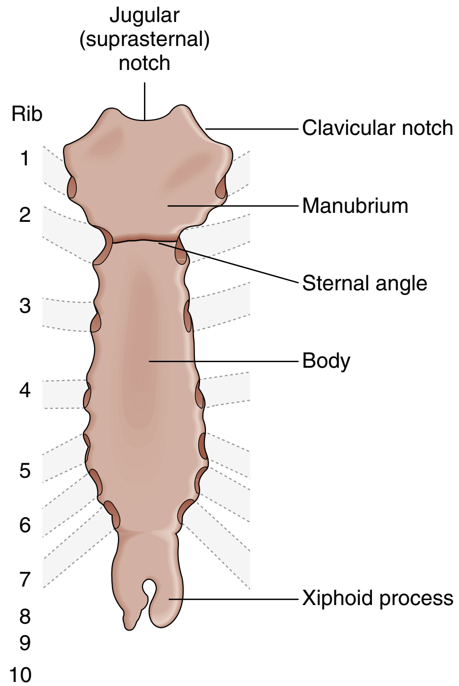

Fig 15.2 The sternum and its attachments.

and patients will often present, or return, after a week of increasing difficulty, looking grey-faced and weary.

The patient often asks for an X-ray. If the injury is not complicated by a severe or dangerous mechanism, the sternum and spine are not tender, there is no sign of injury to the organs and there are no medical factors, then X-ray findings do not influence management. The usual practice is to treat the patient on clinical grounds alone. This is something you will have to explain to the patient. However, X-ray *is* indicated in some cases, and you must assess each patient fully.

EXAMINATION

History

Ask for general social information including occupation and hobbies, especially sports. A rib injury takes about 6 weeks to settle. It has adverse effects on movement of the trunk and arms, the ability to run, lift, climb ladders and many other activities. Consider the implications of the injury for the patient's daily life and give advice on how the problem will change his routines for the next few weeks. He may also require a sickness certificate from his general practitioner (GP) if he is absent from work for more than a week.

Ask if there is a history of respiratory illness, which may predispose to chest infection after a rib injury. Does the patient have any heart problems? Does he take oral steroids or warfarin? Is he a smoker? If so, how much?

What was the mechanism of injury? Is pain local to the injury? It is common for patients with rib injuries to feel an encircling pain from front to back on the same side as the injury. This reflects the shape and position of the injured rib. When did the injury happen? If the injury is days old, why has the patient come now? The patient may be needing help with pain control or may be developing a chest infection. Has the pain changed in location, severity or nature, or in the factors which bring it on? The pain can be severe even though the injury is not complicated in any other way. Does the pain feel as if it is on the surface, or deep, and does it radiate to the neck or arm? Is the patient short of breath, as opposed to having pain when breathing deeply? Has he coughed or vomited blood? Does the patient feel unwell in any way: sick, dizzy or faint? Does the patient have any symptoms in the abdomen? Is there blood in the urine?

Physical examination

Ask the patient to expose the chest.

Begin with airway, breathing and circulation (ABC). A patient with a pneumothorax or a worsening chest infection may show signs of respiratory distress. Observe the effects of respiration on the muscles of the neck and ribs. The patient may look ill or cyanosed. Severe pain may result from multiple rib fractures and these may have caused a pneumothorax.

Record the patient's vital signs. Look for any systemic signs of lung injury, internal bleeding or chest infection. An accurate respiratory rate is required. Tachycardia and low blood pressure may indicate internal bleeding. Record the oxygen saturation: a small pneumothorax will often cause the reading to fall slightly below 97%. If the floating ribs at the back are injured, perform a urinalysis. Look for signs of frank bleeding in the urine and for microscopic traces on the dipstick.

The patient's trachea should be sitting in the midline of the front of the neck. Deviation of the trachea is a sign of a tension pneumothorax on the opposite side to the deviation.

Look at the movement of the chest. Is there asymmetry in breathing? Are the ribs in the painful area moving with the others?

Palpate the spine and the sternum. A transverse process is the most likely structure to be injured in the thoracic spine. The apex of the heart lies close to the sternum and a tender sternum may indicate not only fracture but injury to heart or its large blood vessels. If the sternum is tender the patient will require chest and sternum X-ray and an electrocardiogram (ECG).

Listen to the patient's chest with a stethoscope for equal air entry to all lung fields, and any wheeze or crepitus.

Palpate the ribcage. If the injury is to the costochondral junction, tenderness will be felt at the junction of rib to cartilage. A pneumothorax can cause surgical emphysema: this creates a crackle under your hand like popping bubble-wrap blisters. Remember that you are not specifically attempting to make a musculoskeletal diagnosis, but you should observe any signs of an unusually severe injury: if the patient has multiple fractures this increases the risk of deeper injury and there may also be a need for admission for pain control and chest physiotherapy.

Ask the patient to lie supine on a trolley: palpate the abdomen and lumbar region. If the patient is tender or the abdomen is rigid, a doctor should exclude injury to liver, spleen or kidneys. The spleen is tucked under the costal margin on the left and the liver on the right. The kidneys are in the lumbar region.

X-ray will normally be requested for a patient with a rib injury in the following cases:

- The mechanism has been severe, including falls from a height, road traffic accidents and injury involving great weight and force, such as may happen with industrial machinery. Such injuries will not normally present to minor injury areas.
- The patient seems to have a multiple rib fracture, or a severe osteochondral separation. Fractures to the first three ribs tend to be the result of a severe injury, and underlying complications are likely, especially injury to nerves and large blood vessels.
- There is any suggestion that the spine is injured.
- There is a possible fracture of the sternum.
- There is any suggestion of a haemothorax or pneumothorax, or contusion of the lung.
- There is a history of respiratory illness, or the appearance of respiratory complications. A patient would not necessarily have an X-ray because there seems to be a chest infection. If the patient has no long-standing medical problems, it may be most appropriate to refer to the GP.
- The patient is elderly.

Other forms of imaging are appropriate for patients when you suspect injury to the liver, spleen or kidney. Refer the patient to the appropriate specialist (often a surgeon) in your area.

TREATMENT

Rib injuries are not strapped.

Give the patient detailed verbal advice; it is also helpful to have a written reinforcement. Rib injuries require a sustained programme of self-help, and patients often come to hospital when their own efforts have failed.

The patient will need painkillers. A combination of paracetamol and ibuprofen is often the treatment of choice if the patient has no gastric or renal problems and does not suffer from asthma. The double prescription means that the patient can take painkillers seven times in the day. Given that you will ask him or her to undertake several painful sessions of deep breathing and coughing, and that the injury tends to disturb sleep, this is useful. Take ibuprofen with meals, and save a dose of paracetamol for bedtime. Much of the trunk's rotation occurs in the thoracic area and this means that turning in bed is a constant source of night-time disturbance: 4 pain-free hours will be valuable.

Advise the patient to incorporate several sessions of deep breathing and coughing into the routine of pain relief. The injured site is supported with the hands while the patient inhales deeply and breathes out slowly; this is repeated several times, and then the patient should cough. If a patient finds deep breathing very painful it can help to lie down and lift the arms above the head. This will open the ribs and the subsequent breathing exercises will involve less painful movement of the ribs. This procedure is repeated at least six times per day; it will hurt, but it helps to avoid a chest infection. A good fluid intake and steam inhalations can help to loosen secretions. The patient should examine the secretions for discolouration indicating bleeding or infection.

If the patient has trouble with movement from lying to sitting or sitting to standing, it can help (especially if a rib is fractured) to take a 'half breath' and hold it during the movement. This splints the fracture and reduces pain.

It is not usually considered helpful to advise a patient to stop smoking while struggling with a rib injury. The injury is wearing and the chances of coping with addiction withdrawal at the same time are less than optimum. Smokers also tend to develop a cough in the early days after stopping and this is an extra burden on a tired patient. However, the main late complication from a rib injury is a chest infection and it is reasonable to suggest that the patient cuts the smoking to a minimum to reduce the risk. This reduction might offer a platform for stopping the habit when the injury has settled.

The first 1 or 2 weeks will be the most painful. The patient may have to take time off work and will certainly not be fit for heavy exertion for possibly 6 to 8 weeks. The GP can issue sickness certificates.

The patient who has discoloured sputum or is feverish should see the GP. However, if the patient develops haemoptysis or breathlessness he or she should go to the nearest emergency department. If the patient has microscopic haematuria on urinalysis, with no frank bleeding, there is no immediate need to refer to a surgeon if other aspects of the examination are normal. Give the patient a sample bottle and advise him or her to have the urine retested by a practice nurse in a week. The patient should also keep an eye on urine output until things settle down.

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Part 4

Wounds and burns

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Wounds and burns

CONTENTS

INTRODUCTION

A wound is a break in the skin. Our skin is the boundary between ourselves and everything else: it is a frontier, a place with defences and alarms and border posts, and a successful breach is felt in the whole organism. Patients with superficial wounds often believe that their injuries are more serious than they are (and they may also underestimate certain wounds, such as an innocuous-looking puncture or a painless division of a tendon): the frightening, visible aspect of a wound, the torn skin and the blood, may tell us little about the deeper significance of the injury; but the pain and the physical stress that occur when the skin is broken are not less because the wound is uncomplicated.

Nevertheless, serious injuries are usually obvious, from the history of a severe mechanism, from the evidence of the wound itself and from the appearance of the patient. It is not common to find a patient sitting quietly in the waiting area of a minor injury unit (MIU) with an unannounced, life-threatening wound. There are, however, some exceptions and you must look for these, especially when the injury is to the midline of the body.

The principles for managing injuries to the limbs and to the midline of the body are the same whether the injury is open or closed. In the limbs, the deep structures are the big three of the musculoskeletal system, bone, muscle and joint, including the ligaments, and also the blood vessels and nerves. In the midline, the major organs are better protected from the violence of a moderate blunt injury than from any kind of penetration: a wound is a threat to any major organ in its vicinity and we assume the possibility of a life-threatening injury even in the case where the patient walks into an MIU. The difficulties in diagnosis and decision-making are less than for closed injuries because the level of precaution is so high. It is usually too dangerous even to disturb a wound of this kind and your job will be limited to triage measures, referral and transfer of your patient to the appropriate surgeon.

Initial problems

Patients usually have minor wounds under control by the time they reach an MIU. There is usually a rough pressure dressing in place, controlling the bleeding and reducing the pain. The patient will not be likely to faint if the dressing is not touched. The nature of the wound will be hard to predict from the appearance of the dressing so prepare to manage bleeding before removing it. Bring the patient to a treatment area and let him or her lie down on a trolley.

Bleeding

Bleeding will stop if some swabs are put over the wound and direct pressure is applied with a gloved hand. In the case of a limb wound, elevation will reduce the flow of blood. A few minutes are enough to stop an ordinary venous ooze from a small wound. If an artery is divided the bleeding will be pulsing and spurting. This will require more prolonged pressure to stop it, and it may alter the plan for managing the wound. Assess perfusion beyond the injury:

- Is there good colour and warmth?
- Are pulses present?

- Is capillary refill time equal to the other limb?
- How much blood has the patient lost?
- Are there signs of low circulating blood volume? Is the patient pale and tachycardic, has his or her blood pressure fallen?

Arterial bleeding will usually stop with direct pressure, but it may be necessary to maintain pressure for a long time. Small but persistent bleeding arteries are sometimes tied off. On rare occasions the problem may require surgical intervention.

Bleeding is a factor throughout the treatment of a wound, and it can make exploration and closure difficult. With a hand wound, elevating the bleeding part often solves the problem. Epinephrine (adrenaline) can be introduced into some wounds along with local anaesthetic to cause vasoconstriction, but it is not used in wounds to peripheral parts such as fingers, where there is a theoretical risk of ischaemia. Tourniquets of various kinds can also be used but this requires care to avoid injury to vessels and ischaemia. Time the use of the tourniquet and, above all, do not forget to remove it. If you are working in an MIU without medical support, and you are having difficulty managing bleeding, this may indicate that the patient should be referred on for a more formal exploration of the wound. Deep structures in the limbs are packed into a small circumference and they often travel together: injury to one is a predictor for injury to others. When bleeding is a problem, assessment of the other deep structures is difficult. Bleeding is distressing for the patient and it will distress you too if you do not manage it well.

If there is heavy bleeding and glass or metal can be seen in the wound, do not remove the object, press on it or otherwise disturb it. Put swabs around the object and apply pressure proximal to it.

Pain

A patient with a minor wound does not usually complain of pain until the wound is examined. Any pain which is caused during examination will settle if treatment is completed rapidly.

The key to a comfortable exploration of a wound is adequate anaesthesia.

In MIUs, many patients have small, superficial wounds (1 cm or less), which are painful to treat but which have a tiny risk of complications. The patient's reason for coming is that 'it wouldn't stop bleeding'. (Usually, by then, it has stopped, and it starts again when it is examined.) It is unpleasant to receive a local anaesthetic, and, in some sites such as the hand, it can be as painful as the treatment. It is, therefore, reasonable to ask the patient to put up with the discomfort if you are sure that a small flap wound will be cleaned, explored and closed with paper strips in a matter of a minute or two.

If the wound is not complicated by any injury to deep structures, but needs suture (wounds with a Stanley knife to the fatty tissue of the thigh are a common example), a local anaesthetic is necessary and there is no point in cleaning or exploring the wound before it is given.

In almost every circumstance where a wound will require opening, cleaning, exploration and closure, local anaesthetic should be used at the outset. The smallest disturbance of a wound is very painful. Cleaning and exploration have to be carried out patiently and thoroughly, and you must feel that the patient is comfortable and you are at liberty to do your job properly.

The time factor

The treatment of wounds, especially in cases where closure is an option, is time critical. Three factors are relevant:

- Bacteria invade a wound from their usual home on the skin and from the world beyond, from the moment of injury: from there they go down, marauding and multiplying and seeking the conditions in which they can overpower the whole system. If the wound is not cleaned out at once the risk of infection increases and closure may only make things worse.
- A wound begins to heal from the moment it is inflicted. A formal wound closure brings the injured skin together so that the torn edges will bond to each other through the healing process. This cannot happen if the separate parts have sealed off before they are united.
- Deep structure injuries can become more severe over time: a large tendon tear may become a complete tear; divided tissue tends to retract over time so that it is harder to bring it together.

These factors mean that a patient with a wound requires an initial assessment which is both prompt and accurate.

Faint

If it takes a few minutes to clean, explore and close a small hand wound, the patient is likely to feel faint. Always settle a patient with a wound comfortably on a trolley. Some patients are happy to lie flat while you work on the injury. Others resist this. Do not assume that a patient who sits up and watches everything you are doing will not faint. Watch the patient and make sure the backrest can be easily reached. Patients become pale before they faint. If patients lie down at this stage, they will soon feel better. Relatives in the treatment room may also faint.

Blood-borne infection

A wound is a potential hazard to any health worker who comes into contact with it because of the risk of blood-borne infection. Your patient is a stranger to you and you

may not have much background information. You run the risk of contracting hepatitis B, C and human immunodeficiency virus (HIV). Be rigorous in your precautions against contact with the patient's body fluids. The patient is also entitled to be protected from you, a health worker in a high-risk environment. Always use gloves and other available equipment such as visors when they are appropriate.

Your local occupational health and infection control departments will have policies and procedures in place in your area for the protection of patients and staff. These will cover a variety of matters such as protective equipment, immunisations against hepatitis B, the cleaning up of contaminated spillage, and needlestick injuries (Boxes 16.1 and 16.2).

Box 16.1 The skin

- A body system for protection from heat, injury, trauma and infection. It regulates temperature through blood supply and sweat glands and has a large supply of sensory nerves. It is supported below by layers of fascia.
- All layers are present everywhere but thickness varies with body site, age and health. Most skin is 1–2 mm thick. Skin on the back can be 4 mm thick.
- For wound closure the skin layers must be aligned, epidermis, dermis, superficial fascia (subcutaneous or subcuticular layer) and deep fascia.
- Epidermis (or cutaneous layer) is the outer protective skin layer. It has squamous epithelial cells. It has no vessels or nerves. It allows the release of water and salts. It is only a few cells thick and cannot be seen separately from dermis during repair. It aligns if the wound edges are matched. Its base layer, the stratum germinatavum, provides cells to repair injured epidermis. The stratum corneum is the keratinised outer layer.
- The dermis is below the epidermis. It is much thicker, made of connective tissue, mainly fibroblasts, which build collagen, the main component of connective tissue. It also contains macrophages, mast cells and lymphocytes, and these are active during healing. It has two layers, the papillary, which nourishes the epidermis, and the reticular, which contains blood vessels and hair follicles. Nerve endings are found in both layers. Dermis is visible and is the key structure for accurate wound repair. All sutures, superficial and deep, should be anchored in dermis. If it is damaged it should be debrided, but only the unsaveable tissue. The aim is to minimise scarring. If it is divided it should be closed
- Below dermis is the fatty layer of subcutaneous superficial fascia. It provides insulation and padding against injury. It can harbour clots and dirt and grow infection if devitalised. It can be debrided freely. It has the risk of creating dead space. Sensory nerves pass through it to dermis and local anaesthetic should be injected between superficial fascia and dermis.
- Deep fascia is a dense fibrous base for superficial fascia, and it is also wrapped around muscle in layers. It separates structures and helps to isolate infection.

TYPES OF WOUNDS

A wound is a break in the skin. There are three types of wounds, defining them by their causes, surgical, pathological and traumatic. The wounds which concern us here are those caused by trauma. A traumatic wound can be one of several types. The distinctions between them are important for assessment and treatment. Describe the wound accurately in the notes. The following terms are used to describe wounds:

- A **cut** is a break which has been **incised** into the skin by something with a sharp edge such as a knife, razor blade or glass. These wounds look neat and tend to be relatively easy to close. The main concern with cuts is the ease with which soft deep structures like nerves, tendons and blood vessels may be divided.
- A **laceration** is a break in the skin caused by blunt force. The skin has been burst rather than cut. These occur only in places where the bone is near the surface such as the top of the head or the shin. Essentially the injured soft tissue has been crushed between two hard surfaces, the external object and the bone. A laceration will look more ragged than an incised wound. It may be **contused** (bruised). Blunt violence may complicate treatment. There may be brain injury or damage to any vital organ; there may be fracture. Swelling causes pain and compromises distal parts and makes suture inadvisable. Dirt and devitalised tissue carry a high risk of infection.
- A **penetrating** wound is caused by something long, pointed and narrow. The term **puncture** is often used to describe penetrating wounds on the hand or sole of the foot caused by nails, garden rakes or fence spikes. A penetrating wound looks like the least of wounds. The lurid, superficial signs are usually absent. There may be no external bleeding or bruising, and only the tiniest break in the skin. They are the most difficult of wounds because you lose the usual clinical advantage of broken skin: you cannot see what is going on below, you cannot see the base of the wound and you cannot achieve a satisfactory wound toilet. A puncture over the vital structures of the midline is an emergency until

proven not. Over the limbs your usual dilemma is whether there is deep structure injury or a high risk of infection. This is often expressed as a single question: 'do I need to refer this patient for exploration of this wound?'

- An **abrasion** is a graze, an injury caused by friction shearing the skin away. It is usually a combination of superficial and partial thickness trauma, but a severe mechanism can produce a much deeper wound. There is usually a 'halo of inflammation' around the overtly damaged skin in superficial injuries. Abrasions are common in patients who have fallen off bicycles. Minor abrasions can be as painful as a superficial burn. Unfortunately, they are often very dirty, with embedded grit, mud and burned-in discolouration in an area of raw tissue. It is vital to clean an abrasion properly for two reasons. The first is infection. The second is a cosmetic problem. New skin which forms over superficial dirt will preserve it but not hide it, and the patient will have a permanent tattoo. Cleaning may require the use of inhaled nitrous oxide, local anaesthetic (either infiltrated or applied topically), a nail or toothbrush and forceps. Minor debridement is sometimes needed. Children with grazes may need to be referred for surgical management. A large abrasion may take a long time to clean, but stick at it. It is important to do a good job.

Box 16.2 Wound healing

- Inflammation – fibrinogen aids coagulation, platelets release growth factor, phagocytes remove debris.
- New circulation and lymphatic vessels start granulation.
- Epithelial cells grow over the wound from its edges.
- Fibroblasts and collagen fibres appear and the process becomes organised.
- Fibrous tissue matures into the final scar.
- At 1 week the wound has <10% of original tissue strength.
- At 6 weeks most of the strength has been regained.
- At 1 year the tissue is <80% of original strength.
- Children heal faster than adults.
- Initial appearance of a wound gives little clue as to the final outcome. It may improve, or there may be an undesirable appearance caused by contraction of the scar.
- Black skin may lose pigmentation for up to a year, and Afro-Caribbean individuals can develop keloid scars.
- Healed skin may burn more easily in the sun for a year.

WHEN IS A WOUND MINOR?

It is more or less axiomatic that a wound is less likely to be minor if it is in the midline of the body: but there will be many wounds, especially to the head and face, that you will be able to treat and many limb wounds which you will have to refer to a surgeon. You may regard a wound as minor if it presents no complications which oblige a referral of the patient to a doctor. Such complications may include:

- problems with exploration
- problems with cleaning or closure of the wound
- concern about the size, depth or site of the wound
- concern about the mechanism of wounding, such as extreme violence or a human bite
- a high risk, based on the history and examination, that a deep structure is injured and requires repair
- concern that the wound threatens a vital organ.

Factors which complicate wounds

A main feature of a traumatic wound, compared with a surgical incision, or even with a pressure sore, is the amount that is unknown, uncontrolled and variable about the cause. This means that the priority of management, and the source of most of the problems, is not the closure or the dressing of the wound but the assessment of a range of risk factors which attend the injury. These factors are different from one patient to another. The history and, in particular, the mechanism of injury are the best guides to the possible hazards in any case:

- Open **fractures** can occur with blunt trauma which causes a laceration. In crush injuries, the wound may be dirty and the fracture comminuted. There is a risk of bone or joint infection.
- The risk of **infection** is increased by the presence of dirt, devitalised tissue and haematoma and by a delay in treatment. Puncture wounds and human and animal bites carry risks which will be described below.
- For our purposes **foreign bodies** are described in two groups: those that are **radio-opaque** (visible on X-ray) and those which are **radiolucent** (Box 16.3). Radio-opaque objects include metal, glass, grit and tooth. Wood, a common foreign body, is not radio-opaque, although it may be visible on X-ray if it is covered with a metal-based paint. Ultrasound may detect

Box 16.3 Foreign bodies in wounds

- Glass, metal, tooth and bone are radio-opaque – request SOFT TISSUE VIEWS from your radiographers.
- In the case of strong suspicion of a non-radio-opaque foreign body, ultrasound may be appropriate.

foreign bodies which cannot be seen on X-ray. If there is a strong reason to suspect that a foreign body is present in a wound, refer the patient for investigation.

- **Damage to an underlying structure** must always be excluded for any tissue which lies within reach of whatever has given the wound. Over the midline this may include an injury to a vital organ. In the limbs, the tissues that may be affected are the nerves, blood vessels, bones, joint structures and muscles. The commonest site of accidental wounding is the hand: it combines power, finesse and mobility in a structure which is not bulky. One of the reasons for this is that much of its power is generated from a distance, from above the elbow, and transmitted along a network of long, cable-like structures, the tendons, which travel almost to the tips of the fingers. These tendons, and the nerves and blood vessels which accompany them, lie just below the skin, on top of an unyielding surface of bone. They are vulnerable to division by cutting or crush. The hand also has a large number of delicate joints in a small area and they are vulnerable to penetration and to division of their stabilising ligaments.
- If a wound which requires suture is more than 6 hours old and it has received no treatment, it is deemed to be a **late presentation**: it is assumed that infection has started to develop. Primary closure (see below) may not be appropriate. In fact, it may be acceptable to close the wound if other factors are favourable (such as an absence of dirt and devitalised tissue in the wound), but you should only do this if you have the knowledge and experience to make that decision and if you know how to adjust treatment to minimise the increased risk. Do not close a wound if you are doubtful.

ASSESSMENT AND EXPLORATION OF WOUNDS

Some considerations have already been discussed, the mechanism of injury, the patient's lifestyle, medical history and medications (with particular interest in antibiotic and topical allergies, anticoagulant, immunosuppressive or corticosteroid medicines, and a history of diabetes). These will inform an assessment of the patient and the wound.

This section will focus on factors specific to the wound.

The injured tissue

The assessment of a wound will cover not only the extent of the damage but also the viability and health of the injured tissue. Important factors will include the patient's age, the site of the injury, the patient's health, the quality of the circulation and nerve supply at the injured area, the frailty of the skin, whether or not the wound will affect a major function such as walking or eating, and the cosmetic significance of the wound.

Exploration

A fundamental concept is not to close a wound until you have seen its base.

The purpose of wound exploration is to discover the extent of the damage and the threat to the injured tissue. The main categories of problem that will be assessed are damage to underlying structures (see above); the presence of devitalised tissue, which will cause infection; the presence of dirt; and the presence of other foreign materials (commonly, wood, glass and metal).

These risks cannot be assessed if the wound cannot be seen clearly. There must be a good light source (preferably an adjustable spot lamp). Bleeding and pain must be under control.

The initial unpleasantness of bleeding and tearing of skin can make a superficial wound seem worse than it is. The lack of those signs can make a penetrating wound seem trivial. The tendency to underestimate innocuou-looking wounds is not confined to patients, and you must guard against it. Be extremely curious about every aspect of a wound and answer all of your questions before it is closed. It might be expected that an open injury would be easier to assess than a closed one such as a sprain, simply because the access to the damaged tissue is greater. Often, this is not the case.

Penetrating wounds are, by definition, longer than they are wide, and for all that they are open, they are not accessible. Any worrying feature, dirt, foreign body, penetration to a vital area, will lie deep. Penetrating wounds can be assessed indirectly, by probe (do not probe wounds which are near vital organs), and by testing the function of the underlying structures. They can be cleaned by irrigation (if the fluid is able to drain from the wound: there is no point in redistributing dirt to even more inaccessible parts). They can be X-rayed for foreign bodies. However, except in the cases where surgical exploration is required, they resist a comprehensive inspection and full cleaning. They are prone to many complications and can threaten life and limb.

The difficulty of assessment is not, however, confined to penetrating wounds. Wounds are intrinsically deceptive. Once a wound has stopped bleeding, a clot forms, and the deeper layers of the wound can be covered and held together. Subcutaneous fat is a globular, clustered material and it can be hard to tell if it has been penetrated. Anyone who has experience of wound assessment will remember cleaning an apparently shallow wound which has suddenly popped open to reveal a much deeper injury. This becomes more likely when the wound is a few hours or days old.

Another factor which leads to concealment of the extent of an injury is that the different tissues under the skin have varying degrees of mobility. If a patient closes his fist and punches through a pane of glass, cutting his knuckles and partly dividing his extensor tendon, there is no point in lying the hand flat to explore the wound. The tendon moves over a greater distance than the skin when the hand is opened and closed, and the divided part will no longer be visible in the wound. Find out what position the hand was in when it was injured and explore the cut in that position. The patient will not always know the position in which the wound occurred: inspect it through the whole range of movement under a direct beam of light. Lift the skin edges and look beneath for injuries beyond the exposed parts and do this too while taking the nearest joints through their full range of movement.

A related problem is that tendons which are completely divided by an injury will shrink or be pulled away from the wound by the contraction of muscles and the movement of joints. There is no comfort in the fact that a tendon cannot be seen in a wound if there should be one there. You must know the relevant anatomy to assess the wound. Supplement a visual inspection by tests of the function of the local tendons, nerves and circulation and inspect the nearby joints for signs of penetration or instability.

Another difficult feature of wounds is that many of the common complications develop over a period of hours or days. The signs of infection do not usually appear in the first few hours. The loss of sensation which heralds a damaged sensory nerve may deepen over days. A partly divided tendon may fulfil its function, although its action will probably be weak. Later, it may divide completely. Complete division of the central tendon of the extensor mechanism of the finger, at the proximal interphalangeal joint (PIPJ) may be concealed by the fact that the lateral tendons will continue to work as extensors of the PIPJ, perhaps for days; however, the boutonnière deformity will develop eventually. There will be little hope of a good recovery at that stage.

A sterile, round-tipped wound probe can be a helpful aid in wound exploration, for assessing depth in places that cannot be seen and for detecting, by touch, hard foreign bodies. Probes should be used very gently, and only in places where they will do no harm. A small curved mosquito forceps is a useful retractor.

When exploring a hand wound do not tie bleeding vessels: they are often very close to nerves. Do not excise any tissue, it is hard to replace and there is little to spare. Debridement may be necessary but it should be done by a specialist. Do not probe with anything sharp. The only sharp things you should use are needles for anaesthetic and suturing.

The term 'exploration' has been used here to describe a process which is performed in an MIU for a limb injury. A full exploration of a difficult wound, or a wound in a dangerous place, is a surgical procedure, done in theatre conditions with good anaesthesia and instruments, and with the skills and resources to deal with any problems which arise. Do not go too far. It is easy to stray out of your depth when dealing with wounds.

Other tests for complications

Consider the risks to any patient whose wound cannot be seen to its base. If the wound requires further exploration a surgeon may extend it in theatre. The indications for further exploration include, among others, a wound over a vital area, the known presence of a foreign body of fair size, a strong suspicion that a deep structure has been injured or the presence of dangerous contamination.

There are three main methods, in a minor injury clinic, to supplement exploration to exclude complications.

Observation

Observe for external signs of complications. The local signs of wound infection are pain, redness, heat, swelling, offensive discharge and odour, failure to heal and ascending lymphangitis (the 'tracking' red line moving proximally). The lymph nodes in the area may rise (often in the axilla or groin) and systemic signs, pyrexia and malaise, may develop.

Test of function

Test the function of parts which may be injured. Always assess the nerves and circulation distal to the injury. Test that the patient can feel light touch, that pulses are present and that the colour and temperature of the tissues are normal. In a skin loss injury, assess sensation over the whole exposed area to exclude a full-thickness wound.

Test tendons carefully. There are two main concerns.

- A problem may be overlooked, for example if a particular function is carried out by more than one muscle and only one of them is damaged.
- Tendons which move distal joints will also contribute to the movement of every joint that they pass over. Tests can be used which isolate the single tendon that is giving concern.

A tendon injury can be worsened, for example if there is a piece of glass in a wound and the tendon is mobilised over it, or if a tendon is partly divided and the test completes the job.

A tendon test should be applied against resistance to be conclusive, with power compared with the other side. A patient may retain active movement by using a substitute tendon, or a partly damaged one, but should not have full power. This test has the potential to worsen damage. Do not do it if there are already grounds to think the tendon

is cut. Apply and release the resistance gently, and stop at once if there is weakness. Sometimes the pain of the wound prevents the patient from using full power.

Radiography

X-ray can be used to exclude bone injuries where an open fracture is possible and to reveal metal or glass foreign bodies. Other imaging options are available, usually after a patient has been referred to a surgeon.

WOUND CLEANING

Consensus is lacking on certain matters which surround the subject of wound cleaning. Some recommendations, such as those on the role of antiseptics in cleaning, are prone to pendulum swings, which makes confident practice difficult. Topics which are debated include the effectiveness of chemical cleansers in reducing infection and the toxicity of cleansing agents to healthy cells in the wound. In spite of this, the clinicians whose writings are current have a large core of agreement on the advice that they offer for day-to-day treatment of acute wounds.

There are given reasons for cleaning a wound, and a recent, untreated, traumatic wound should always be cleaned thoroughly. However, some wounds should be left undisturbed. If a wound is not new, and is dry, clean and healing, with no signs of infection, you should leave it. It is also wise to advise patients on such matters. There can be a tendency to overuse powerful disinfectants at home (Box 16.4).

Reasons for wound cleaning

Infection

A thorough wound toilet is the key measure which will reduce the risk of infection in the wound. This includes procedures such as debriding necrotic or contaminated tissue, evacuating haematoma and getting rid of foreign matter, both small particles of dirt and larger objects. What constitutes an effective wound toilet depends on the nature of the wound and the infection risk factors which apply to the particular injury.

Box 16.4 Asepsis and safety

- Ensure that your own immunisations against tetanus and hepatitis B are up to date.
- Wear gloves when dealing with wounds.
- Observe hand washing and aseptic procedure routines.
- Dispose of any sharps promptly and personally.
- Clean up any blood spillage.
- Clear away your own equipment.
- Never resheath needles.
- Deal with any needlestick injury in line with your local policy.

Cosmetic

We have already discussed the need to remove all dirt embedded in an abrasion so that it will not form an unwanted tattoo. The cosmetic issue is also linked to the question of infection. An infected wound will not heal, sutured edges will break down, the wound may have to be reopened, and any scarring will be worse than it need have been (Box 16.5).

Exploration

A wound cannot be explored if it is covered in dirt, and the discovery of foreign matter of any kind in the wound, which may cause infection, inflammation or injury, is one of the objects of exploration. Cleaning and exploration are reciprocal activities which are discussed separately but carried out together.

Box 16.5 Cosmetic outcomes for wound closure

- The scar develops over a year.
- Final appearance depends upon the patient and upon events.
- Infection, diabetes, vitamin C deficiency, collagen disorders, renal failure, corticosteroids, chemotherapy and immunosuppressants contribute to poor scars.
- Poor outcome increases with extremity wounds, wide wounds, poorly apposed wounds, associated tissue trauma, use of electrocautery and infection.
- Scarring depends on static and dynamic tensions at the wound.
- Static tensions stretch the skin on bone when the patient is still.
- Dynamic tensions stretch the wound when muscle or joint movement occurs.
- Langer lines are the directions of minimum static tension in the body. Wounds which follow these have better outcomes. Wounds which cross them perpendicularly have poorer outcomes.
- Scar width is related to the force required for closure. Methods to reduce wound tension include tissue undermining (dividing the dermis from the subcutaneous fat to reduce tension in the skin edges) and deep suture.
- Gaping of wound at rest and in motion gives an estimation of the potential outcome.

Cleaning agents

Water

The effective removal of dirt, as opposed to bacteria, is more a matter of *how much* and in *what manner* rather than *what* fluid, and the ordinary tap is the best source of an unlimited supply.

Saline

Normal saline is widely used for cleaning wounds, both for wiping the wound edges and for irrigation of the open area. It is isotonic and so will not irritate the cells of the damaged tissue but neither does it have any antiseptic effect.

Povidone iodine

Povidone iodine is a combination of substances of which the active agent is iodine, an antiseptic which acts against Gram-positive and Gram-negative bacteria as well as fungi and viruses. The preparation of povidone iodine which is used as a surgical scrub contains a detergent which is not intended for use in open wounds. Trott (2005) recommends a 1% solution of povidone iodine in saline for wound periphery cleansing. It retains its antibacterial effects with no apparent toxicity problems.

Chlorhexidine

Chlorhexidine is an antibacterial agent which Trott (2005) describes as having strong Gram-positive action but, perhaps, a weaker Gram-negative action than that of povidone iodine. He cites a particular benefit in the use of chlorhexidine as a hand cleaner. It can build up on skin and apparently suppresses bacterial activity over a longer period than other cleansers. He also recommends it as a wound periphery cleanser. He advises against using the detergent-based hand-scrub in the wound itself.

Methods of wound cleaning

Lacerations and cuts

The need for adequate anaesthesia has already been discussed above.

Continue cleaning until there is no visible dirt in a wound and the tissue has a pink, fresh look, possibly with a little bleeding.

Cleaning is taken in two stages:

- The edges of the wound, where tissue is intact, are wiped as vigorously as is required to clean away all visible dirt and blood. The technique is to wipe away from the edge, using a wet gauze swab, so that no contaminants or microbes are carried into the wound. A patient who is covered in oil or paint may need to use a solvent skin cleaner such as Swarfega to clean the skin, avoiding the open wound.
- Irrigation is the best way to clean an open wound area because rubbing or scrubbing can damage wound cells, and materials like gauze or cotton wool can leave strands in the wound. The best way to achieve a reduction in bacteria in a wound is to irrigate under high pressure, regardless of which cleaning material is used. Irrigation is also effective for removing a good deal of visible dirt. If there is serious contamination, other techniques may also be required. High-pressure irrigation is described slightly differently by different clinicians, but the commonest recommendation is to use a 20-ml syringe with a 19-gauge needle and direct fluid from very close range, at full power, into the wound. This is said to create a pressure of 8 psi. A large amount (up to 500 ml) may be required. Splash guard precautions should be taken and there may be a fair amount of mess.

Penetrating injuries are, by their nature, impossible to clean in a satisfactory way, but high-pressure irrigation can be used on the punctures which commonly occur to the sole of the foot or the hand, which do not require surgical exploration, provided that you are able to achieve drainage of the fluid from the puncture.

Abrasions

The particular reasons for the need to clean abrasions thoroughly have already been discussed earlier in this chapter.

A fresh abrasion is very painful. Cleaning may have to be vigorous, often with a brush, and some pieces of dirt may need to be picked out from little sacs of skin with needle or forceps. Dirt may be ingrained like a permanent stain and may not surrender even to scrubbing with a brush. Children are often injured in this manner and the management of a child's distress may be difficult.

There are topical anaesthetics available for use with children for both grazes and suture. They must be properly applied to soak into the affected site and they must be left for the time required for them to take effect. Such agents sting on application but this settles quickly and they make cleaning possible without resorting to a general anaesthetic at least in some cases. It is also possible to infiltrate a small graze with an injection of lidocaine. The usefulness of injected local anaesthetic for cleaning abrasions is restricted because larger grazes require amounts which exceed the maximum dose. Extreme care has to be taken in this regard with children. Abrasions which are large, or which are on the face, may require cleaning under a general anaesthetic.

If you are considering treating a child, think carefully about the possible problems, and refer if there is any doubt.

Debridement

Wound cleaning is part of a continuum which includes surgical procedures to remove contaminants and devitalised tissue. That degree of contamination influences other issues, such as wound closure and antibiotic prophylaxis. Debridement also raises the question of the function of the damaged tissue and measures to minimise any loss. There can also be cosmetic implications. These are matters for specialist surgeons. Your role is to recognise the issue, avoid errors such as inappropriate closure and to refer the patient.

WOUND INFECTION

Infection is the main complication of traumatic wounds. The steps to prevent infection in a new wound are an important contribution to healing. You will also see and treat established infections which are still local to the area of the wound. If the infection is moving beyond the wound or the patient is ill, he or she may need admission to hospital for intravenous antibiotics and surgical management may also be considered.

What is a wound infection?

The skin, along with other areas of the body, is colonised by **commensal** flora. These are microorganisms which coexist with each other and their host and cause no illness as long as they are checked by their neighbours and remain in a dynamic, virtuous state of balance with them. A wound, a break in the skin, allows these microbes to penetrate where they should not be. It also involves the violent invasion, through the barrier of the skin, of some implement from the dirty outer world, shedding its own load of microscopic life forms. The patient then visits a hospital and is exposed to the infection hazards which medical treatment entails.

An organism which multiplies to an extent where it causes harm to its host is called a **pathogen**. The harmful process is an **infection**. The infective organisms are called **bacteria**.

Bacteria are subdivided into groups by their shape, their response to laboratory staining and their need of oxygen. Three bacteria are mentioned here. A fourth, which causes tetanus, will be discussed in greater detail below.

Staphylococcus aureus is an aerobic Gram-positive bacterium and it appears, from the frequency with which it is cultured from swabs, to cause most of the traumatic wound infections which are seen in hospital. It is highly resistant to penicillin but sensitive to flucloxacillin and erythromycin. It is a commensal, found in the nares and other sites where there is hair or mucous membranes. It can cause superficial wound infections and abscesses, osteomyelitis and septicaemia. The toxin-producing variety can cause the fatal **toxic shock syndrome**, which is best known in relation to tampon use.

Streptococcus pyogenes is also a Gram-positive aerobic bacterium, and another common offender in traumatic wound infections. It is sensitive to penicillin and erythromycin. It is a commensal in some people and is found in the mucous membranes. It also causes cellulitis and can cause necrotising fasciitis, septicaemia and toxic shock.

Clostridium welchii is an anaerobic Gram-positive bacterium. It, and other organisms of the same family, cause gas gangrene infection, a dire threat to life and limb. It is a commensal of the human gut and is found in soil. It can form spores and lie dormant in a protective shell, highly resistant to destruction, until conditions are suitable for it to multiply. Anaerobes flourish where oxygen is lacking. Wounds with devitalised tissue are ideal ground for reproduction. The reproducing organism creates gas, hydrogen and nitrogen, and exotoxins, which consume healthy tissue and threaten systemic collapse. *Clostridium welchii* is sensitive to penicillin.

The wounds which are prone to anaerobic infection are those with violent tissue destruction under dirty conditions, such as war injuries and farmyard accidents. As a general rule, these are severe injuries and will not be seen in an MIU. Among the wounds which you are likely to see, dirty, penetrating wounds which are difficult to clean at the base are at the greatest risk of anaerobic infection.

A patient who is at a high risk of anaerobic infection may require a combination of prophylactic antibiotics and surgical treatment, with delayed closure of the wound if closure is necessary. (Closure of a dirty wound is a positive encouragement to anaerobic infection.) Refer such patients promptly.

The increasing danger of infection by bacteria which have high resistance to common antibiotics and the communal responsibility on prescribers to conserve these precious medicines mean that the management of potentially infected wounds is evolving. The value of thorough wound toilet and sound aseptic technique during treatment is to the fore. Prophylactic antibiotics should be used only where the evidence supports their value. The clinical diagnosis of an infection which requires medications should also be sound.

When is a wound infected?

A microbiology laboratory will describe a wound as infected if certain levels of bacteria are cultured from a swab. Such levels can often be found in a traumatic wound which has not yet been cleaned and is showing no signs of infection but is more than 6 hours old. This is why it is preferable not to suture such wounds.

Laboratory assessment is not of great practical value to you. First, you will be treating wounds on their clinical appearance, and with the benefit of no more than a few minutes with the patient. Second, you will not take swabs unless an infection is already suspected, and initial management of the problem must be decided before a result is received. Third, a positive laboratory finding would not usually lead to treatment of the wound as infected when there are no clinical signs or other risk factors.

The treatment of a wound as infected is based on clinical judgement of two types of factor: indicators for a high risk of infection and clinical signs of infection.

Factors which create a high risk of infection in a wound that does not appear to be infected include:

- wounds which require closure but are not treated for more than 6 hours
- wounds which are very dirty
- wounds which contain devitalised tissue
- penetrating wounds
- bites, animal or human
- the patient is immunocompromised.

A patient with such a wound may be given prophylactic antibiotics (although this may not prevent infection) in addition to the care which the wound itself receives. The decision to give prophylactic treatment is one that is made in compliance with local guidelines, both for clinical management of the patient, and for the decision on which antibiotic to prescribe. These guidelines should be based on the best current evidence on the effectiveness of prophylaxis in reducing the incidence of infection. Remember that overuse of antibiotics endangers us all and that the majority of patients who receive a prophylactic antibiotic would not have developed an infection.

There are a number of clinical signs of infection:

- Pain beyond the expected level (which is usually not great in a healing wound), or worsening instead of settling, suggests infection. Pus collected under a wound causes a throbbing pain. Examine local structures, including tendon, bone and joint, for tenderness and other symptoms which suggest a spread of infection.
- Redness is a normal feature of a healing wound, but it should not spread beyond the immediate wound edge. Trott (2005) gives the distance as 5 mm. Spreading redness or redness which tracks proximally, **ascending lymphangitis**, are signs of infection. Assess the rate of spread and mark its boundaries with a pen so that further assessment can be made.
- Local heat is a sign of inflammation. Assess local structures for spread.
- Swelling can be caused by pus, a localised fluctuant swelling or a general inflammation. If structures such as joints or bursae are swollen, the patient needs orthopaedic review to exclude a joint sepsis. Certain structures, such as the palmar spaces of the hand, can develop abscesses, which need orthopaedic review and drainage.
- A wound which remains moist may be infected. Closed wounds should become dry very quickly. Abrasions may exude serous fluid for a few days, but then they should develop a dry fresh granulation. Persistent exudate is a sign of inflammation, and infection is a probable cause. Pus is a sign of infection.
- A wound which does not heal but is not developing any florid signs of infection should be swabbed for culture. This kind of problem is not seen in an MIU very often. It is a late complication and usually the patient has moved on to the primary care team by then. Obtain a medical opinion. If a wound is not healing you need to know why. A grumbling infection is one, but not the only, possibility. Scarring may be worse if the issue is not settled, and wounds on the lower leg can ulcerate. There may be a foreign body in the wound, a deep infection or an underlying medical complaint. If the patient is a diabetic, has circulation problems or wound healing difficulties for any other reason, there is a risk of gangrene.
- An offensive odour may indicate anaerobic bacteria, a possibility which is greater if the wound is deep, a dirty puncture, one with devitalised tissue, a large haematoma or an animal bite.
- Raised lymph nodes proximal to the injury indicate an immune response to infection. Assess the axilla or the groin, looking for a difference on the affected side: pea-sized, firm swellings and tenderness.
- Systemic signs of infection may occur, especially feverish shivering. A patient may look pale, tired and unwell, or flushed and sweaty. The patient may complain of malaise, aching joints, tiredness, anorexia or upset stomach. The patient's temperature may be raised and the pulse faster than normal.

Treatment of an infected wound

Abscess

A collection of pus, with a painful, fluctuant swelling but no signs of tracking or systemic infection, can be treated by opening the swelling, draining it and letting the open wound heal under the supervision of the practice nurse.

Local treatment is sufficient if there is no cellulitis or other signs of spreading infection.

Cellulitis and spreading infection

A wound should be treated with antibiotics if it shows a spreading redness, a **cellulitis**, an ascending lymphangitis, or it involves bone or joint, shows signs of tissue death, threatens sensitive areas such as the eye (ask for a doctor's opinion of any infection of the face) or is accompanied by malaise.

The infection may require specialist intervention, such as joint aspiration and lavage, wound debridement and, in some cases, life-saving measures to treat septicaemia or toxic shock. Where systemic infection is suspected, blood may be taken to assess the white cell count, C-reactive protein and erythrocyte sedimentation rate and for culture, to exclude septicaemia.

Treatment is offered on a wide scale, depending on the nature and degree of the problem. When an infection is no longer localised, the patient may require intravenous antibiotics, requiring admission to hospital or referral to an outpatient intravenous therapy service.

You are likely, depending on your role, to offer definitive treatment where the problem is very localised and to make a referral when a more serious infection is apparent. If a patient is treated without referral, give full advice, so that the patient will return if the infection gets worse or does not improve.

Tetanus

The Joint Committee on Vaccination and Immunisation issues national guidance from the various Departments of Health (DoH) in the UK in the form of its *Green Book: Immunisation against Infectious Disease*. This is available online. The information in this section is largely based on that source.

Tetanus is the disease caused by ***Clostridium tetani***, an anaerobic Gram-positive bacillus, which forms spores. *Clostridium tetani* is a commensal of the gut, found in humans and most particularly in grass-eating animals. It passes into the soil, where it can survive as a spore until a suitable host is found. The organism enters through a wound and multiplies in an anaerobic environment, which the injury is more likely to offer if it is a deep puncture, if there is devitalised tissue, haematoma, or if other infection is present. The organism produces an exotoxin which attacks motor nerves. It travels up into the central nervous system and triggers the disease tetanus. The disease may incubate from 4 to 21 days.

There are very few cases of tetanus in the UK because there is a well-organised immunisation programme. Nevertheless, reducing its incidence, even to zero, will not eliminate this disease: the spores are out there and always will be. Any patient with a wound who has not been immunised is at risk.

The history of the immunisation programme in the UK indicates that two main groups have received immunisations: everyone who was born after the early 1960s (the full national immunisation programme began in 1961) and older people who served in the armed forces from the Second World War onwards. Therefore, older women are statistically the most likely group to be at risk.

A patient can be given temporary, but immediate, immunity by the injection of another person's antibodies: this **passive immunity** is obtained from a dose of **human tetanus immunoglobulin**. This comes in ampoules of 250 IU and is given by intramuscular injection. Passive immunisation is a supplement to, not a substitute for, vaccination. The normal dose is 250 IU but this is doubled for wounds which are older than 24 hours and for heavily contaminated burns.

A child receives a three-dose initial course of vaccine in infancy, followed by two booster doses at 5 and 15 years approximately. This is, according to UK guidelines, probably enough to protect for life. However, the World Health Organisation does recommend that a sixth booster in early adulthood may be added.

For an adult who has not been immunised, give a dose of vaccine, and arrange for two further doses, each spaced 4 weeks apart, so that a whole course is completed in 2 months approximately. After that, the patient should have a booster dose of vaccine after 10 years, and once more after a further 10 years. See below for the use of immunoglobulin in patients who have an incomplete immunisation status.

The conditions which are likely to lead to infection are a combination of anaerobic tissue, acidic conditions and contact with the spore. It is therefore vital that a thorough and effective wound toilet is carried out in every case. An open, well-irrigated wound inflicted by a clean blade does not carry a high risk: a deep puncture from a manure-coated pitchfork in a field is a different matter.

The DoH risk classifies the risk of infection by the combination of two strands of the presentation.

Certain wounds are considered to be **tetanus prone**:

- untreated wounds which are more than 6 hours old
- where there is devitalised tissue
- punctures
- contamination by soil or manure
- infected wounds
- a wound with a foreign body
- an open fracture
- the patient has systemic sepsis.

The second strand derives from whether a tetanus-prone wound is combined with other **high-risk** circumstances:

- Has it occurred in a place or a way that makes contact with the pathogen likely?
- Is there an extensive amount of devitalised tissue?

Immunoglobulin is not given for a tetanus-prone wound alone if the patient is up to date with, or has completed,

an immunisation programme. If the incident is high-risk and the wound is tetanus-prone, immunoglobulin should be given *regardless of the patient's immunisation status* (DoH 2014).

If a patient has an unsatisfactory history of immunisation, if boosters are overdue or the history is unclear, the threshold for giving immunoglobulin moves from a combination of tetanus prone with high risk, to tetanus prone alone. If there is any doubt that the patient has ever had a course of adsorbed vaccine, give the first injection of the course, and a dose of immunoglobulin, and arrange for the course of adsorbed vaccine to be completed.

Injecting drug users have at least two tetanus risks: the material they inject may be contaminated with the spore and the tissue which receives the injection may have current infections which encourage anaerobic growth.

The only contraindications which are listed for adsorbed tetanus vaccine are the presence of an acute febrile illness, unless the wound is tetanus-prone (so that a developing illness will not be mistaken for a reaction to the vaccine), and a clear history of a previous anaphylactic reaction to the vaccine. The vaccine is not live so there is no contraindication for pregnant women.

The only common adverse reaction is a local, painful, red swelling around the injection site, which may last for a few days.

WOUND TREATMENT

Medical treatment does not repair wounds. The body does that itself. There is, however, scope for intervention to optimise healing, prevent complications and undo damage that nature cannot correct.

If natural processes will see a wound healed, there is no virtue (and perhaps some risk) in any intervention. Understand the process of healing and its problems and ensure that treatments have a clear aim and the likelihood of improving the outcome (Boxes 16.6 and 16.7).

Wound healing and the scar

The healing of musculoskeletal injuries has been described in Chapter 4. That process applies to wounds. Healing occurs by the same stages of inflammation, proliferation and maturation. It usually results in an imperfect replacement of the damaged tissue with scar tissue (superficial burns and grazes, where the germinal layer of epithelium is unbroken, can heal without scarring).

The difficulties which a scar can cause in tissues like ligament and muscle have been discussed and scarring of the skin over a joint can lead to restriction of movement. However, the commonest concern which patients feel about wound scars is their visibility. The term 'cosmetic' has an unfortunate association with ideas of superficial appearance and frivolity. In wound care, it is a vital part of good treatment, connected to notions of self-esteem and confidence and even mental health. It may have an impact on

Box 16.6 **Factors which influence wound healing**

- Site of wound – the lower leg heals slowly, the face heals quickly.
- Blood supply – the face heals well because it is vascular.
- Wounds over joints tend to heal more slowly.
- Good closure technique and careful handling of tissue.
- Tidy wounds have better outcomes.
- Cause of wound – incised heals better than crush.
- Delay in treatment – infection.
- Patient's health, nutrition and medications.

Box 16.7 **Examination of a wound**

- Site/character of wound.
- Distal functional deficit of deep structures.
- Clean and inspect, irrigate with water or saline, use a syringe or IV giving set – look for damage to deep structures, dirt, devitalised tissue and foreign body.
- Is the wound a crush? Is there pain, swelling, fracture, soft-tissue damage, contamination? Consider need for X-ray, trephine, analgesia, local anaesthetic. Is closure advisable?
- Is the wound a puncture? Clean as thoroughly as possible, consider deep foreign body and dirt, assess deep tendons, nerves and joints. Is X-ray needed? Are antibiotics indicated?
- Is the wound a bite? Consider X-ray, risk of infection to deep structures, risks of closure, antibiotics.
- Is the wound more than 12 hours old? Should it be closed? Will antibiotics be needed?
- Is the wound infected? Does the patient need antibiotics? Should admission be considered?
- Can the wound be closed? Consider suture, Steri-Strips, staples and glue.
- If not, consider dressing.
- CAUTION with wounds:
  - over joints
  - on the head
  - on the face
  - on the neck
  - on the trunk
  - on the genitalia.

personal relationships and employment. In cases where the appearance of the wound is not sufficiently considered during treatment, the patient may sue.

The process of wound healing can be summarised as follows. A wound exists from the moment the skin is broken. There is bleeding. The injured skin retracts, closing off small injured vessels at its edges, and other processes (vasoconstriction and the activation of coagulation mechanisms) lead to the development of a clot within a few minutes. The inflammatory phase begins, to combat infection and clear away wound debris by phagocytosis. It lasts for some days. Overlapping with this activity, the base layer of the epithelium starts to propagate the cells of a granulation tissue which covers the wound, usually generating the new cells into the wound from its edges. The processes of establishing new blood vessels, and the development of collagen from fibroblasts, herald the formation of the scar. It will develop, with remodelling, over many months. It will gain in strength, and shrink, and become pale and avascular.

It will not be possible to evaluate the cosmetic effect of the scar fully until this process is complete.

The aims of wound treatment

Wound treatment is intended:

- to repair any damage to deep structures
- to remove foreign material from the wound and minimise the risk of infection
- to promote healing of the skin with the minimum of scarring.

The first two of these points are discussed in other sections. The success of the third stage will depend, in part, on the care which has been shown in the first two, especially the second. The condition of the wound, in terms of such factors as the time elapsed since injury, dirt and swelling, skin loss, devitalised tissue and the risks of a bite injury, will also dictate the approach to the last stage of treatment. There are several options.

Wound closure

Wound closure is the process of bringing the divided tissues in the wound together, **opposition**, in the anatomical position which the injury has disrupted, from base to surface of the lesion, and stabilising them in that position until they begin to heal (Box. 16.9).

Wound closure has functional benefits. It gives the damaged layers of tissue the best chance of resuming their previous relationships and roles. The scar will be minimised and healing will be quick. The wound will have some external support, and this may allow the patient some use of the injured part while it is healing.

There is a distinction between closure of the layers of tissue, skin, fat and fascia and repair of vital structures: bone, blood vessels, nerves, joint structures and tendons. A tidy opposition of the separated edges, with a minimal scar and a minimal loss of function, is the aim of closure. Repair of a specialised tissue, such as a flexor tendon in the hand, is more difficult. Simple opposition of the separated tissues may not restore function.

It is important to reassemble the separated layers from wound base to skin, rejoining each level of tissue, and leaving no gap, no **dead space**, where infection can develop.

Layered closure may sometimes be desirable because the wound tends to gape. A surface closure may not offer sufficient support. The wounds edges may be under great tension, which restricts the blood supply, makes the scar worse and carries the risk of reopening after the sutures are removed. A deep, absorbable suture will reduce tension on the wound edges.

Approaches to closure

It is preferable to close a wound but closure may occasionally increase the risk of complications: wounds with a high risk of infection, wounds which threaten to swell and wounds with frail skin which is poorly perfused may be better managed in a different way. There are also wounds where closure may, or must, be achieved, but the risks are too high to perform it at once.

Primary Closure (Primary Intention)

Primary closure is the preferred pathway: the immediate closure at the time of first treatment of a low-risk wound. The wounds which are closed in minor injury clinics are in this category.

Secondary Closure (Healing by Secondary Intention)

Healing by secondary intention refers to the method of care for wounds which may not be closed and which will be left to granulate. The main option, in this case, if the final scar is not acceptable, is the grafting of skin to the site.

Small, cosmetically unimportant wounds can be treated by this method in the MIU but any which are more difficult will need referral, possibly to a plastic surgeon.

Delayed Primary Closure (Tertiary Closure)

A wound which has a high risk of infection may be left open for a few days and then closed. The levels of microorganisms in the tissue will be reduced by the patient's own defences and by your treatment which may include prophylactic antibiotics in some circumstances. The wound may require 'freshening' at the time of closure, making the edges bleed to restart the healing process.

Closure with Steri-Strips

Steri-Strips are sticky, porous, reinforced paper tapes used in long narrow strips for wound closure. There are several products of this type.

The *advantages* of Steri-Strips, over sutures, are:

- they are cheaper
- they can be applied very quickly, with minimal preparation and very little equipment
- they are painless to apply, making local anaesthetic unnecessary; this is of great value with children
- there is less traumatic tissue handling
- they can be used on frail skin which would not sustain a suture
- they are non-invasive, leaving no scars and no extra wounds, causing no irritation and reducing the risk that you will introduce an infection
- they are not prone to the complications of poor suture technique
- patients can usually remove them themselves at home.

The *limits* and *disadvantages* of Steri-Strips are:

- they can only be used for superficial wounds; they cannot close a dead space
- they have to be kept dry
- they are less robust than sutures on an area like the hand and patients may be able to perform more of their normal activities with sutures
- they will not stick in areas where there is hair
- there can be problems if they are used on very mobile skin, such as the extensor joints of the fingers. You will give the patient a plan for mobilising the wound as healing progresses, but the strips may impede this.

Application of Steri-Strips

Steri-Strips are supplied in 3 mm width, which is very useful for small, not very tense, superficial wounds. A strip of 6 mm can be used on larger areas. (These are often valuable for pretibial lacerations.)

Steri-Strips will usually stick, with no other adhesive, if the skin is well cleaned and dried (Fig. 16.1). A problem with adhesion may indicate that there is too much skin tension (in which case a wider strip or suture may be more appropriate) or that haemostasis has not quite been achieved.

It is not usually necessary, with small wounds, to use the full length of the strips, and they are often inconvenient at full length. If strips are used on fingers or toes, they should not pass circumferentially around the digit as they may restrict circulation. If you intend to put an adhesive dressing on top of the strips then the dressing pad should cover the strips entirely to prevent them being pulled off when the dressing is changed.

The strips are porous, but it is recommended that a space is left between them of approximately 3 mm (ie, equal to the width of the narrow strip). This allows exudate to escape without causing the strips to peel.

Fig 16.1 The application of Steri-Strips.

Wound closure is usually started at about the middle of the wound. Align the borders, using any irregularity or skin crease to match the sides. Place strips alternately above and below the first strip. This helps to hold the edges in accurate opposition and keeps them in equal tension. The first strip may need to be re-sited at the end.

Strips may be applied with sterile forceps for an aseptic technique. Place half of the strip on one side of the wound, bring the edges together by pressing the other side into gentle opposition and then passing the strip over. Repeat that over the whole wound.

Place two rows of strips, one on either side of the wound parallel to the wound, across the transverse strips to anchor them.

Closure with an interrupted suture

The insertion of an interrupted suture (Fig. 16.2) requires the use of local anaesthetic and sterile instruments.

Local Anaesthetic

Lidocaine is the most commonly used infiltrated local anaesthetic (Box 16.8). The hazards associated with its use are allergy and toxicity.

Allergic responses are not common, but they can be extreme, including anaphylaxis. Ask the patient for any history of allergy to local anaesthetic. Observe the patient for signs of local reaction, rash, and any signs of swelling or systemic distress.

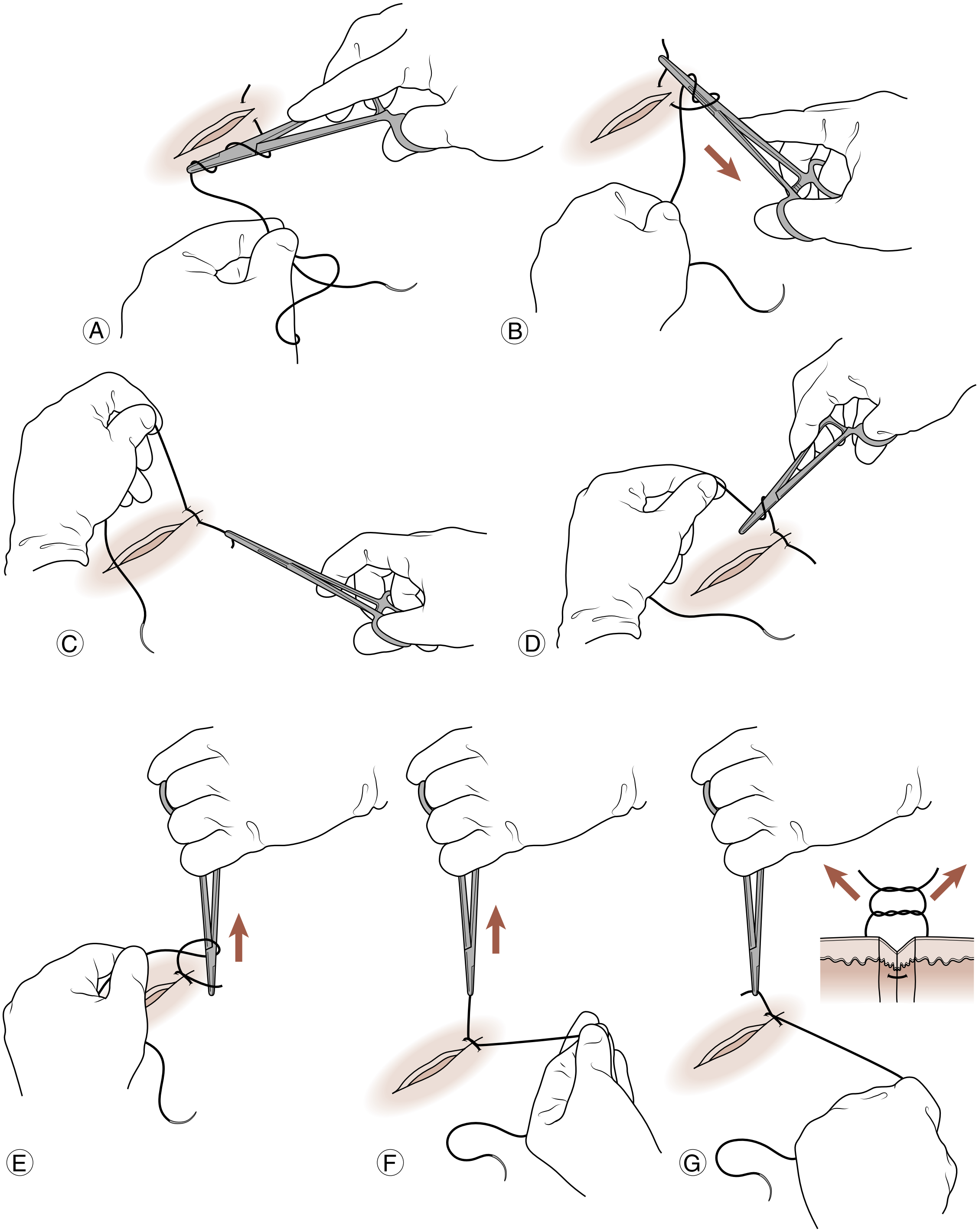


Fig 16.2 Closure with an interrupted suture. A, To evert the wound edge, introduce needle at 90° angle to the skin. B and C, Pass a double loop round the needle holder. Clamp the free end of the suture and pull it through to the first knot. D, Pass a single loop in the opposite direction from the first knot, round the top of the needle holder and clamp the free end of the suture. Note in the boxed illustration the final square knot configuration. E, The position of the suture in a well-everted wound. Note that the knot is to one side of the wound. Align all knots on the same side of the wound.
Source: From Trott, A., 2005. Wounds and Lacerations, third ed. Mosby.

Box 16.8 Lidocaine

- Toxic in overdose: signs include tingling of face, seizure, cardiac arrhythmia.
- Safe dose 3 mg/kg (0.3 ml of 1%) average adult up to 20 ml 1%.
- Lidocaine with epinephrine (adrenaline) is used for vasoconstriction and haemostasis. DO NOT USE ON SMALL STRUCTURES such as fingers, ears, nose. It can cause ischaemia.

Box 16.9 Methods of wound closure

- Suture – gives the strongest closure but is very traumatic for children; sometimes would require general anaesthetic.
- Staples – quick but painful and cosmetically dubious, best reserved for scalp.
- Glue – good for superficial closures with good haemostasis. Take care near eyes, and do not get stuck on your patient.
- Steri-Strips – versatile and useful for children. Biggest disadvantage is they can come off early, and cannot get wet.

Toxicity is most likely where the patient receives an overdose of lidocaine or there is accidental injection into a blood vessel. The main toxic effects are to the central nervous system and the heart, causing convulsions and cardiovascular collapse. The patient may appear euphoric, speech may be slurred and the patient may complain of light-headedness, tinnitus and numbness around the mouth. If the clinic is not in a hospital, start resuscitation and transfer the patient as an emergency. If in hospital, commence resuscitation. The priority is airway, breathing and circulation (ABC). Give oxygen. Venous access will be needed for fluids if blood pressure falls and to give diazepam if convulsions develop.

The safe dosage of lidocaine is 3 mg/kg of body weight. Lidocaine 1% contains 10 mg/ml, and the maximum dose for an adult is 20 ml. Take care in the calculation of a child's dose.

The addition of epinephrine (adrenaline) to the anaesthetic causes local vasoconstriction. This reduces bleeding in the area, which makes exploration and closure easier. It also slows the absorption of the lidocaine into the circulation, which prolongs its anaesthetic effects. There is concern that smaller extremities, including the fingers and toes, the nose, the ear and the penis, may suffer ischaemic necrosis from such vasoconstriction, and epinephrine is contraindicated for those areas.

Lidocaine 1% is not so dense in its anaesthetic effect as a stronger concentration and 2% is more reliable for use in ring block anaesthesia to the digits. After lidocaine has been given the patient will feel pressure and tugging on the tissue being treated but will not feel sharpness or pain. The duration of anaesthesia varies, but it is approximately 30 minutes.

Infiltration Infiltration of lidocaine (also called lignocaine) is shown in Figure 16.3. Draw up the injection, after calculation of the amount to be used and the safe dose for the patient. In practice, the need for a dose that approaches the adult limit would raise the question of whether this wound is minor. Use a fine needle to reduce the discomfort of penetration.

When infiltrating, remember the risk of intravenous injection. Draw back on the syringe before each compression of the plunger.

There are two common methods of infiltration. Trott (2005) says that injection directly into skin meets with great resistance and injection into deeper fat delays the action of the anaesthetic; consequently the superficial fascia, just below the skin is the proper level for infiltration. Injection can occur through the open wound edges just below the skin. This avoids the discomfort of penetrating the skin but is not advised if the wound is dirty. A sequence of small injections around the whole wound will achieve the purpose. Injection through the skin is started at one end at a little distance beyond the wound (to ensure numbing of the near corner of the wound). Pass the needle as far along as it will reach and withdraw it while injecting until lidocaine is infiltrated to the near corner. Without withdrawing the tip, the needle is then passed along the other side of the wound, repeating the process. If the wound is longer than the needle, the remaining part on each side can be anaesthetised fairly comfortably by passing the needle through skin which is already numb.

Digital Block Anaesthesia (Ring Block) For the treatment of wounds on the fingers and toes, and for some other painful procedures such as incision and drainage of a paronychia or the removal of a splinter from under a nail, it is usually preferable or necessary to achieve local anaesthesia by blockade of the digital nerves (Fig. 16.4). This is achieved by injecting lidocaine *without epinephrine* (adrenaline) into the dorsal finger at its proximal end.

The technique is more invasive than wound edge infiltration and will require training and supervision, in accordance with local policies, to ensure safety and competence.

Potential hazards are:

- intravascular injection of lidocaine
- too much fluid in the small circumference of the finger, threatening compression of the blood vessels and ischaemia.

The targets of the blockade are the four digital nerves which run along the digit close to the bone; there are two

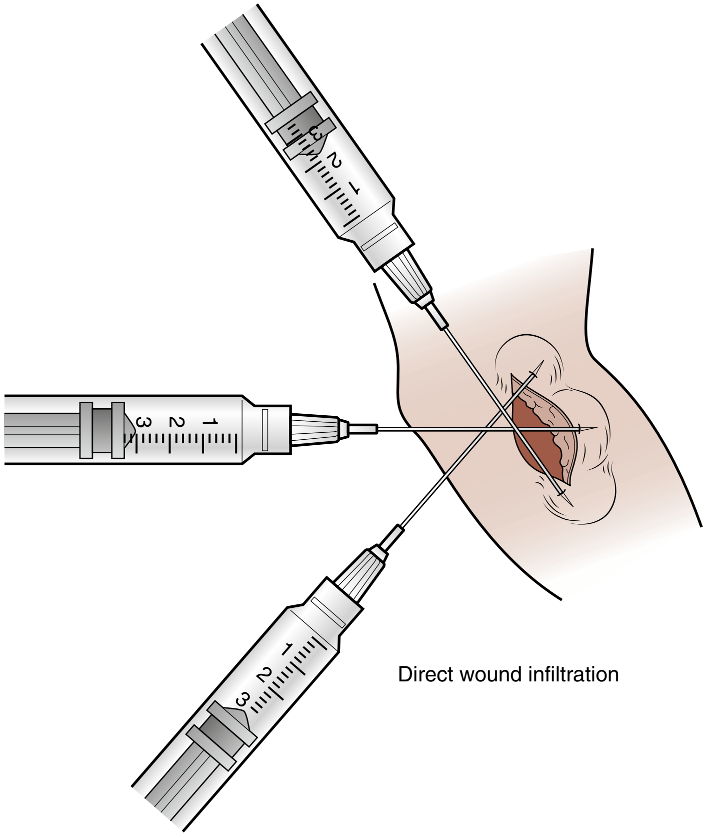


Fig 16.3 Wound edge infiltration with lignocaine. *Source:* From Trott, A., 2005. Wounds and Lacerations, third ed. Mosby.

on each side, one on the palmar aspect and the other on the dorsum.

There are variations in the recommendations for technique and dosage between various experts, but the use of lidocaine 2% is advocated, and the amount to be injected is set between 2 and 4 ml.

Once the injection has been given, it takes 10 minutes for it to take effect, and the patient's sensitivity to sharpness should be tested before proceeding.

Lat Gel for Children This is a topical application, named for the three ingredients, lidocaine 4%, adrenaline (epinephrine) 0.1% and tetracaine 0.5%. It can be used on a child over 1 year old for cleaning, exploring and even suturing wounds. It therefore represents a considerable advance in the reduction of distress associated with suture for children. It cannot be used in any site where its vasoconstriction effect would endanger the tissue, so this excludes digits and other small peripheries and skin flaps. It must be applied with care to ensure absorption and left for half an hour before treatment is begun. Soak it into a swab and let this lie in the wound under an occlusive dressing. The maximum dose for children ages 1 to 3 years is 2 ml; 3 ml is the maximum above that age. Approximately 1 ml is required for each centimetre of wound length.

Suture Materials

Superficial interrupted suture is the main technique which is required in an MIU. Interrupted suture is the placing of a series of separately tied sutures in a wound to close it, as opposed to techniques where some form of continuous suture is used.

The fact that the closure is superficial means that a non-absorbable material is used. It will remain visible and accessible and it must be removed when it has served its purpose. A curved reverse cutting needle is usually considered to be appropriate for closure of skin in traumatic wounds because of its combination of strength, sharpness and smoothness of action. This needle has a triangular cross-section, flattened on its inner curve, with a sharp edge on its outer border.

A synthetic, monofilament, non-absorbent suture, usually nylon or polypropylene, tends to be the material of choice for work on non-cosmetic areas. These sutures are not so easy to handle or tie as the braided materials (silk,

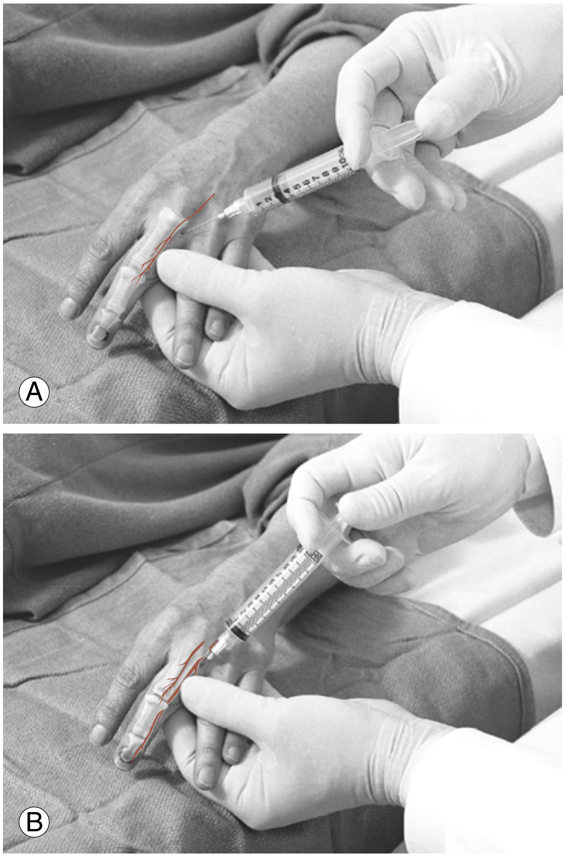


Fig 16.4 Digital block anaesthesia.
Source: From Trott, A., 2005. Wounds and Lacerations, third ed. Mosby.

cotton and nylon) but they seem to have a lower rate of infection, and silk is thought to leave a larger scar.

The gauge of the suture material is denoted by a number, with the lower numbers (eg, 2/0) denoting the thicker sutures and the higher numbers (eg, 6/0) the finer. Thicker material has more strength but is more traumatic. The choice of gauge is largely dictated by the site of the wound. The scalp can be sutured with 2/0, the lower leg with 3/0, the upper limb with 4/0 and the face with 6/0.

Sutures cause additional trauma at a wound site. They make new wounds and lodge foreign material in the tissue. They cause scarring and are infection prone and their removal is preferable as soon as the wound is able to support itself. Fortunately, the most cosmetically significant area of the body, the face, has an excellent blood supply, high resistance to infection and good healing. Sutures must be removed from the face after 5 days to reduce scarring. In the lower leg, healing is slow, and sutures are left in place for 2 weeks. Sutures should be left for 2 weeks at sites where the recently closed wound will be exposed to stress and stretching: on the front of the knee, the back of the elbow and the joints on the back of the hand.

Suture Instruments

Advice on instrument technique in this section is based on Trott (2005).

For work in the MIU, three tools are usually adequate: the needle holder, fine-toothed dissecting forceps and suture scissors. You will have a disposable, sterile suture pack: it may also contain curved and straight mosquito-type forceps, non-toothed dissecting forceps, cleaning materials, gauze swabs and sterile drapes. You will also have cleaning fluid, sterile gloves, splash protection, local anaesthetic and sutures. A patient trolley is needed in a quiet and clean area with good, adjustable lighting and an adaptable and easily cleaned work surface (often a metal trolley). Other useful props include an armrest, which can be attached to the trolley, and the working area should be arranged so that you can work comfortably, preferably seated, without stress on the back.

Needle Holders Needle holders are scissor-handled straight instruments, with a locking mechanism and chunky, serrated jaws to hold the suture firmly. Trott (2005) recommends the 4.5-inch size. The needle should be held only at the tip of the jaws, or it may be weakened by the holder's grip. The needle is held at least one-third of its length from the suture, where it is strongest, at a right angle to the holder. Trott recommends that, for passing the needle into skin, the holder is not held 'scissors style' but is cradled with the fingers around its shaft so that the wrist can extend freely. The thumb and ring fingers should hold the scissor handles when they are used, leaving the index finger free to control the instrument.

Toothed Dissecting Forceps Fine-toothed forceps can damage the tissue which they grip. They are needed to stabilise the skin while it is being sutured. Hold them gently, in the same way as a pencil (ie, lying on the web of the thumb) rather than enclosed in the hand. Grip the exposed subcutaneous tissue rather than the skin itself, to reduce the trauma.

Suture Technique

Suture is usually taught in a single session but you will continue to develop your skill for the rest of your career. The skills required are use of the tools, handling of the tissue and clinical judgement about your treatment, including the anticipation of complications. In addition, safety and infection control are vital and you must pay constant attention to the patient's responses to this traumatic process. You will require supervision of your early efforts and it is probably best to have a structured training programme.

Basic technique involves a number of key points:

- Do not seat yourself until you have considered the best position for working. A wound often has a mobile side and a firm side and you will prefer to pull the mobile side towards yourself. Plan the environment including the lighting, the patient's position, your own comfort and the involvement of other people.
- Get things right. Do not be afraid to remove and replace a suture.
- The wound edges must be rematched exactly. Any skin crease or peculiarity of the wound will help. The first suture is placed somewhere near the middle of the wound. Is the suture being pulled diagonally by skin tension? Do the subdivided areas of wound, above and below, sit together nicely?
- The suture should not be so tight that the skin is blanched. A loss of circulation at the wound edges will prejudice healing, worsen scarring and encourage infection. The wound edges will swell a little during healing, and a slight space between them is better than making them too tight.
- If the wound edges are slightly everted, or turned outwards, after suture, they will flatten out as the scar shrinks, and the final result should be good from the cosmetic point of view. If the edges are inverted, the scar will tend to form below skin level. Placing the needle into the skin at an angle of 90 degrees and letting the suture describe a square as it passes through the tissue should achieve the desired eversion.
- Do not leave the knots over the wound. Site them all on the same side of the wound. This is tidy, which can be important if the sutures are hard to see at removal, avoids irritation of the wound and helps to achieve eversion of the edges.
- The suture should be placed deep enough to close the divided tissue from base to surface so that there is no dead space to act as a refuge for haematoma and infection. The depth of penetration of the needle will depend partly upon the length of the needle and partly upon the 'bite' of skin taken. This means that the needle will penetrate more deeply the further from the wound edge that it is placed into the skin. When the needle is brought out through the skin on the other side of the wound, it should be the same distance from the wound as the opposite needle puncture in order to keep the tension equal.
- No more sutures should be used than are necessary. Trott (2005) offers two pieces of advice: firstly, place just enough sutures to prevent gaps appearing in the wound edges between sutures and, secondly, the distance between sutures should measure about the same as the bite. When you have placed the sutures ask the patient to move the wound a little and watch the behaviour of the edges. If it is straining and gapping you may require revision.

Closure with skin staples

Skin staples have a similar range of application to Steri-Strips as far as the depth of the wound is concerned. They achieve superficial closure only. They are probably most useful on the scalp, for wounds which are not deep but which cannot be Steri-Stripped because of the hair. They are easiest to place where the bone is fairly superficial and presents a firm base to stabilise the wound.

Hold the wound edges together with one hand and position the gun carefully so that the staple will enter at 90 degrees to the skin and will take an equal bite on either side of the wound. Warn the patient before the staple is placed. Press the gun firmly. A hesitant technique can cause the stapler to jam with a staple caught in the skin but still attached to the gun.

Staples cause pain when they are put in, but it is not extreme and it passes quickly. For small wounds, there is little point in using local anaesthetic, which will probably hurt just as much as the stapling and prolong the whole business.

For a superficial scalp wound, staples can be removed in 5 days.

Staples stand up from the skin, which helps when they are taken out but makes hair combing a matter for care. Hair can be washed gently and the wound should be dried carefully. A hair drier will heat the staple and should be avoided.

Removal involves the use of another gadget, a small, spring-loaded, jawed pincer, which bends the staple and pops it out painlessly. This should also be used firmly or the staple may stick. If you send the patient to a practice nurse for removal make sure that he or she has a remover and can use it.

Benefits of staples over Steri-Strips are that they can be used in hair and they can get wet. Disadvantages are that they are painful to put in and they require a return visit for removal. The cosmetic result is not controllable, and they should not be used on the face or hands.

Staples, perhaps surprisingly, given that they are painful to put in, are often successful with children with scalp lacerations, mainly because the procedure ends at the point where the patient is beginning to object. They can be used very swiftly, and the trauma of a prolonged, contested treatment is avoided.

Closure with skin glue

Another agent which can be used to close superficial wounds is a medically adapted version of superglue, a sterile preparation of adhesive which polymerises in the open air within seconds and will seal a wound.

Bleeding must be stopped before the glue is applied, and the edges of the wound must be held firmly closed. The glue should lie on top of and not in the wound, where it would prevent healing.

Glue is applied in a series of spots to the surface of the wound, or in an unbroken line. The glue will become cloudy as it hardens, which usually takes 30 seconds.

There are different chemical compounds, and some glue types require multiple layer applications to achieve full strength, while others require only one layer and are made more brittle by further applications. Follow the manufacturer's advice for the product in use in your area. There are a variety of devices with different products to control flow and to make the application more precise.

Products are available which combine paper strip closure with glue applied to the strip to increase its grip and tensile strength. As external, pain-free closures of this kind develop there may be fewer occasions when sutures are required, a situation which will be particularly appreciated by those who are looking after children.

If glue gets into an eye, flush it with water and leave it to release, which should happen over 2 days. Do not pull at the glued tissue.

Tell the patient that the glued wound will form a scab, which must be kept dry and left alone for 5 days. After that, the glue can be removed by washing.

Glue's advantage is that it is swift and painless. It is limited in use to small superficial wounds, and it is relatively expensive.

Dressings

The economics of the MIU, where patients are treated once and referred to the general practitioner for follow-up, keep the range of dressings simple. There is no incentive to buy expensive dressings when no long-term benefit, in cost or outcome of treatment, will be seen. The dressing needs of most patients with minor trauma are straightforward, and simple measures will usually do.

The use of a dressing should be an answer to a specific need, and it should be done in the knowledge that it will cause no harm and will bring the patient some benefit.

The common reasons why a patient might require a dressing are:

- to reduce pain caused by exposure to the air (see minor burns, below)
- to keep contaminants out of a wound
- to pad and protect a tender wound
- to protect a wound from disturbance, new trauma and irritation, which may include the patient's own fingers in the case of children
- to soak up exudates
- to create the moist environment which is most conducive to wound healing
- to keep a topical treatment or an active dressing, such as Kaltostat, in contact with the skin
- to cover a wound and prevent sticking when the patient needs a support bandage over it (this is common practice with pretibial lacerations).

Dressing practice in an MIU is divided into two main areas: the treatment of closed and open wounds.

Closed wounds

The factors which reduce the risk of wound infection have been listed above. There is no evidence that dressing closed wounds reduces the rate of infection. Some closed wounds on sites which are difficult to dress, such as the eyebrow or the scalp, are usually left uncovered.

The decision to cover a wound at the time of closure is often taken because the wound is still moist. The decision to continue to cover the wound on subsequent days may be taken for various reasons. Steri-Strips and wound glue tend to need protection from moisture and rough handling. Sutures are more robust, but an impact can reopen the wound; chafing from clothes and excessive wetting or contamination from everyday substances may slow healing. Patients who are in contact with food which is served to the public, or who provide medical care, should cover their wounds and may be subject to other regulations and restrictions.

Open wounds

Open wounds which are treated with dressings in the minor injury clinic are of three types:

- wounds which will be allowed to heal by secondary intention because there is a complicating factor which prevents closure, such as an unacceptable risk of infection or the presence of swelling
- wounds where skin has been lost, and closure is not possible; bleeding and pain are often the initial problems with these wounds (these will be small injuries, often to fingertips with kitchen choppers; patients with larger, full-thickness skin losses will be referred to hand or plastic surgeons)
- superficial injuries, sometimes over a relatively large area of skin, of the burn, blister and abrasion types; these are tender and have large amounts of serous exudate.

Types of dressing

Wounds which are cut off from the air or are dressed with a very moist preparation become macerated and break down. Wounds which are completely deprived of moisture are slower to granulate.

Closed wounds have a minimal area of open tissue in contact with the air, and it is enough to give them a dry, porous, non-adherent cover, often some kind of silicone mesh, which will not bond and tear off healing tissue when it is removed.

Open wounds which are exuding and painful can also be covered with a non-adherent woven silicone dressing, which maintains a moist environment. Add gauze on top to soak up exudate.

Deep cavities may have to be packed to prevent them from closing over and leaving a dead space and to absorb exudate which gathers below the level of the skin. They should heal

from the base outwards. Various absorbent substances are used for packing, and for filling wound craters, including alginate dressings (eg, Kaltostat) and conforming hydrogel dressings (eg, Intrasite and Granuflex beads).

Alginate dressing is also used to stop persistent bleeding in skin-loss wounds. It forms a hard shell with the blood and will be difficult to detach from the wound in the next few days (although this can be achieved by soaking the dressing). It will come off as the wound granulates if it is left undisturbed.

Inadine, an iodine-impregnated gauze dressing, is one example of an antiseptic, moist wound dressing.

Securing a dressing

There are two basic ways to secure a dressing: with a bandage or with a sticky tape. There are also newer dressings which can cling to skin without adhesion: these are of particular value for patients with frail skin.

Bandages are less secure than sticky tapes because they tend to slacken and slide, and they are difficult to apply to some parts of the body, but they have three advantages:

- avoidance of tape allergy (always ask the patient about tape allergy when taking the history)
- they do not damage frail skin, often an issue with the elderly patient and those who have been on steroids for a long time
- they can combine the holding of a dressing with an element of compression, which may be useful for bleeding or swelling.

The advantages of tapes are:

- they can provide a less bulky, more firmly anchored dressing
- they can be applied in awkward parts of the body
- they can be adapted around joints to leave the patient's range of movement intact and they can be used to limit movement if that is required.

SPECIAL TYPES OF WOUND

This section will look briefly at some types of wound which are difficult to manage or require special treatment (Box. 16.10, see also, Factors which complicate wound management, above).

Scalp wounds

A blunt wound to the scalp can cause difficulties on its own, but, in addition, the head injury must be assessed, both in terms of neurological signs and symptoms since the time of injury and the risk of a depressed skull fracture.

A scalp laceration can lose so much blood that the patient can become hypovolaemic. The galea aponeurotica is a layer of connective tissue which joins the frontalis muscle in the forehead, covers the top of the head to the occipital region at the back, and passes to the temporal area at the sides. A large tear in this structure can affect the function of the frontalis muscle, which elevates the eyebrows, and also makes it easier for infection to spread to the underlying periosteum and bone of the skull and even into the intracranial space and the brain through the deep circulation. Sub-galeal infection can also cause necrosis of the scalp and a sub-galeal swelling may indicate a skull fracture. Inspect every scalp wound carefully. If the galea is torn, meticulous cleaning and layered closure using absorbable sutures are required. Have a low threshold for taking senior advice for scalp lacerations.

Box 16.10 Wounds to head and face

- Scalp lacerations with deep haematoma can cause intracranial infection, and may need surgical drainage.
- Facial wounds – consider all deep structures and cosmetic issues. Good blood supply means fast healing and low risk of infection. Bites can be closed.
- The ear is at risk of cauliflowering if it swells, and requires regional block.
- Eyelid wounds need ophthalmology referral.
- The vermilion border of the lip requires precise cosmetic repair.

Face wounds

The upper lateral margin of the orbit contains the lacrimal gland and the medial corner of the eye contains the palpebral ligament and the tear duct: wounds to the eyelids can damage these structures. The levator muscle of the upper eyelid can be divided by a wound. This will cause a drooping, or ptosis, of the lid. Any wound to the surface of the eye should be referred to an ophthalmologist.

Deep wounds over the cheek (below the zygoma and in front of the ear) may penetrate the parotid salivary gland and one of the five branches of the facial nerve.

Blunt trauma to the ear, which causes a haematoma, requires referral. The swelling can cause a separation of the soft ear tissue from its cartilage base, which develops into a 'cauliflower ear'. Check the ear canal for internal injury. When a wound to the ear exposes cartilage, there is a risk of infection and tissue death. The cosmetic problems can also be considerable.

Cosmetic implications of face wounds

The cosmetic implications of any wound on the face should always be considered. A lip wound which crosses the lip-to-skin boundary, called the **vermilion border**, must be realigned so that the line of the lip is unchanged. Wounds

which follow the natural lines of the face (so-called Langer lines) are under less tension than wounds which cross those lines, and a scar is less conspicuous if it follows our natural contours.

Neck and trunk wounds

Neck and trunk wounds are emergencies until they have been fully assessed.

Hand wounds

The significance of injuries to the hand and the need to take a good history, including occupation, hobbies and handedness has been discussed in earlier chapters.

The hand contains many superficial, complicated, easily injured structures. The deep structures of the hand are never very far below the skin. Be suspicious of any wound where you cannot see the base. Watch for divided tendons and nerves. Look for a loss of power, a deformity or a loss of sensation (fingers which are 'droopy or twisted'), and relate the findings to knowledge of the local structures.

If there is any chance that there is glass in a wound, request a soft tissue X-ray. Do not check movement around the injury until this risk is excluded. On occasion, an X-ray film will not reveal a piece of glass if it is very small or if it is lying so that it is masked by bone. If the patient is certain, even after a negative X-ray, usually because there the wound is sharply tender, that there is glass in the hand, believe the patient. Proceed on the continuing suspicion that a foreign body is present.

The hand has very little spare skin. A scar over a joint may cause a permanent loss of movement. The loss of a full-thickness piece of skin from a fingertip which is less than 1 square centimetre is likely to heal well without surgical treatment. A regimen of dressing and review in line with local management is appropriate. Injuries with larger skin loss, nail and nail bed involvement, fracture or exposure of bone should be treated by specialists, either orthopaedic or plastic surgeons, depending on the injury, the patient and local conditions. Grafting is sometimes required for significant skin loss.

An open crush injury to the tip of a finger may involve tissue loss, with open fracture and/or exposure of bone and a wound to the nail bed. Request an X-ray. These injuries may need reconstruction of the fingertip, with trimming of the bone and cover of the tip with a skin flap, or removal of the nail and suture of its bed. It is not always possible to see if the nail bed is torn, but the possibility must be considered if the nail is torn out at the root or broken.

Do not suture open crush injuries to the fingertip. They will swell. Steri-Strips can keep the tissue in loose opposition. Avoid circumferential taping. If the wound is too moist to tape, and loose opposition by suture is needed, the patient will have a ring-block anaesthetic.

Subungual haematoma

A **subungual haematoma** is a collection of blood under the nail caused by a crush injury. It causes painful pressure on the nail bed. The treatment is to trephine (make a hole in) the nail. This can be done by heating the tip of a paper clip in a spirit-lamp flame and pressing it gently it to the nail until you feel it give as it passes through. A hole can be bored in the nail with the point of a white, hypodermic needle or shaved with a scalpel. The hot method is quick except when the nail is very thick. The scalpel makes a bigger hole, which probably improves drainage, but the process is slower and hurts more. Trephining will give no benefit if the blood under the nail has congealed, but this can take quite a few days. There is a chance of a helpful result for up to a week.

Trephining arguably turns a fracture in the underlying bone from closed to open, at least in a technical sense. Different hospitals have different policies, some forbidding trephining if a fracture is present, and others allowing it and giving the patient antibiotics as for an open fracture. But it is increasingly acceptable to trephine with no subsequent antibiotics. There is no strong evidence for any of this and change is probably influenced more by a wider, salutary tendency to raise the threshold for prescribing antibiotics. There are some practical considerations if you contemplate trephining in the presence of a fracture: trephining will not completely relieve the patient's pain if the bone below is broken: you will not know whether the patient's pain is coming from the nail bed or the underlying fracture and it will be a more painful business to trephine on top of a fracture. The patient's view is also pivotal because the procedure is about comfort rather than outcome.

Nail bed lacerations

Injury to the nail bed (see Fig. 16.5 for nail terminology) is usually the result of a crush of the fingertip, often in a carelessly closed door, but also as a result of workplace injuries involving machines, hammers and saws. Fingertips are very vascular and heal well. Therefore, with accurate assessment

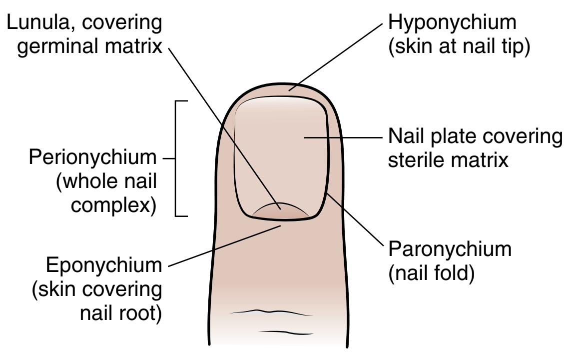


Fig 16.5 Terminology of the fingernail.

and treatment, injuries which look badly torn can do well. A good cosmetic result as well as a return to practical function is desirable where it can be achieved.

There is often a fracture of the shaft or tuft of the distal phalanx with a nail bed laceration, with the broken end of the distal part of the bone projecting through the nail bed and tearing the nail free so that its root lies on top of the eponychium, the skin which is supposed to cover it. This injury constitutes an open fracture as well as a nail bed injury, and the risk of bone infection and the condition and position of bone fragments will be key considerations. The nail may be well enough anchored in its side folds to be covering the actual laceration, which will be visible only as a reddish discolouration under the nail. Sometimes the presence of the laceration is revealed by the fact that it continues beyond the nail bed as a small transverse wound into one or both lateral nail folds. The fingertip will tend to be unstable and the tip may be angled forward at the fracture line, or abnormally mobile there.

Nail bed injuries require a repair which will maintain a smooth surface for the nail to grow again normally. An abnormal angle of the fingertip should also be corrected. If the wound is sufficiently open or mobile to make that doubtful, then the nail should be removed and the defect corrected. The nail, or a prosthetic replacement for it, often cut from the foil of a suture pack, can then be fixed into the nail bed and the nail folds by sutures or Steri-Strips. This will splint the injury, reduce mobility in broken bone and keep the folds patent until a new nail can begin to grow.

Some clinicians do not replace a nail or a substitute after nail bed repair. The arguments for doing so are mentioned above. There is no evidence that not doing so prejudices growth of the new nail. However, it would seem useful if there is a mobile fracture of the distal phalanx to take advantage of the splint value of the nail to align the healing bone and prevent disturbance of the nail bed wound.

The range of management options for nail bed injuries includes repair in the emergency department (ED), surgical toilet and repair in orthopaedic theatre and plastic surgery. The pathway which you choose will reflect the nature of the injury, the facilities and referral options available and the range of skills which are available in your own department (Box 16.11).

Amputations

In an ED you will occasionally be offered the amputated part of a hand, usually part of a finger. Ideally, the part and the patient should both receive immediate attention from different people so that no time is lost. Sometimes the patient can be treated as having a minor injury. On other occasions the patient will need to be stabilised, perhaps resuscitated. The presence of other injuries will modify the situation. For the patient who has no other injury, assess pain, bleeding and the amount of blood lost and take appropriate measures. Fast the patient and initiate preparations for theatre. Other measures will depend on the situation, balancing the desirability of taking steps which will help the surgeon, such as cleaning the wound and requesting X-rays, with the wish to get the patient into theatre as soon as possible. Ideally, the surgeon will be present from an early moment or you will be in touch by telephone.

The viability of amputated parts and the approach of the surgeons vary according to many factors: the time since injury and the delay in cooling the part; tissue which contains muscle belly requires more rapid surgery than tissue which does not; the age, occupation, hand dominance and health of the patient; whether there have been previous injuries at the same site; the exact site of the amputation, whether more than one digit has been lost; the mechanism of injury, whether there has been crush, degloving or a clean cut; whether tissue is lost, badly torn or avulsed from distant parts; contamination of the part and the wound. However, the first task is to optimise the condition of the part until both it and the patient reach the hand surgeon and definitive

Box 16.11 **Nail bed repair**

The procedure for treating a nail bed injury is as follows:

- Ring block the finger and wait until the finger is comfortable.
- Remove the nail by insertion of a small forceps at the fingertip and gently loosen the nail from the plate bed and the nail folds. Release the folds gently to avoid damaging the skin. Ease the nail root skin back where it is still anchored, minimising trauma. Take the nail off. Clean it and preserve it if it is not too badly damaged.
- Irrigate the wound with a large quantity of saline until it is clean.
- Repair wounds in the nail folds before the nail bed, using a non-absorbable suture. This well help to bring the edges of the nail bed wound together. The skin of the nail bed is brittle and can easily tear through, and any decrease of tension is helpful.
- Suture the nail bed with absorbable sutures.
- Re-site the nail so that the bed is splinted and the folds are occupied. Suture the nail in place (two non-absorbable sutures placed at the corners of the eponychium, and one suture at the fingertip end of the nail, the hyponychium, in the centre) or Steri-Strip it. It can be left in place for 1–2 weeks. A prosthetic splint can be made from the foil which wraps a suture.
- Treat any open fracture with antibiotics in line with local policy, dress the injury, advise on elevation and analgesia and arrange review.
- If a nail is loose at a fold, either at the root or the sides, it must be re-sited to prevent adhesion of the fold tissue.

Box 16.12 Amputations

- Tissue preservation should precede decision on value of tissue.
- Preserve tissue in ice-chilled fluid but do not soak or freeze it. Place it in a gauze wrapping inside a sealed plastic bag, and put another bag containing iced water over it.

decisions can be made. Handle the tissue gently and aseptically. Irrigate contamination away as much as possible with sterile saline, wrap the part in a non-adherent material and then sufficient sterile swabs to protect it from contact with ice and tie it into a plastic bag. Place the bag inside another watertight bag, with water and a few ice cubes. Do not freeze the part: chill it. Do not leave it in direct contact with ice. Label it and ensure that it goes with the patient (Box 16.12).

Bites

A bite wound, from a human or an animal (usually a dog or cat), is a complicating factor to a wound from the outset. There is a high risk of infection, aerobic and anaerobic, and management is dictated by this hazard. Human bites carry the risk of transmission of blood-borne infection and will trigger your local policies for risk assessment and blood storage (see below). Exclude injury to bone, joint or other deep structures and the presence of tooth in the wound (tooth is radio-opaque). Bites that may have penetrated a joint require surgical management. Irrigate the wound to reduce contamination. Do not close the wound. Wounds which cannot be left open for cosmetic or other reasons should be discussed at a senior level. Prophylactic antibiotics are often used. This is a matter of local policy, but they are given for deep punctures, when sensitive sites such as the hand or face are injured, when the bite is by a human and when the wound has been closed. The benefits of prophylactic antibiotics for dog bites are particularly well demonstrated by research, for wounds to the hand; the face, in spite of cosmetic issues, is so well perfused that infection is less likely even if the wound has been closed (Boxes 16.13 and 16.14).

Insect bites

An insect bite, often to the leg, can set up an allergic reaction which resembles a cellulitic infection, and sometimes an extremely tender blister will form at the bite.

The patient may complain more of itching than pain if the problem is allergy. Antihistamine (which can be bought at a chemist) is the treatment for allergy. An infection may be accompanied by systemic signs such as raised lymph nodes, pyrexia and malaise. A patient who is not given antibiotics must be told to return if signs of infection develop.

Box 16.13 Human bites

- Ensure hepatitis B cover: give hepatitis B immunoglobulin and start vaccination course if required.
- If previously immunised, check titres – if low treat as above.
- Consider risks of HIV infection: refer for advice on prophylaxis and follow-up.
- Irrigate wound, give prophylactic antibiotics.
- Consider the need for surgical wound toilet.

Box 16.14 Risk factors for bite wounds

High risk:
- Hands or feet
- Large, deep, crush
- Human, cat, pig, primate

Low risk:
- Superficial
- Facial
- Wounds less than 8 hours old

Box 16.15 Flap wounds

Viability of the skin is an issue with all flaps – several factors are important:

1. Perfusion at the site of the injury. Below knee (pretibial) has poor supply.
2. The relationship of the base of the flap, the part which is not divided, to the direction of blood flow (proximal or distal base).
3. The width of the base compared to the length of the flap.

Pretibial flap lacerations

Fragile skin, often secondary to the use of steroid.
- Clean well, remove haematoma.
- Use Steri-Strips where appropriate but NEVER SUTURE.
- Elevate the leg, compression bandage.
- Regular review by practice nurse.

In the case of an infection which is spreading rapidly, the patient may be admitted to hospital for intravenous antibiotics. Ask for a medical opinion if in doubt.

Wasp stings are common in the summer. The patient will have pain at the sting site, with an area of redness and swelling around it. A vinegar pad, if the patient is certain that the attacker was a wasp, eases the discomfort.

Any patient who describes or is seen to be suffering from systemic symptoms after a sting, and especially marked respiratory difficulty and cardiovascular collapse, must be treated for an anaphylactic reaction. The patient will require resuscitation, ABC, with 100% oxygen, intravenous access and intramuscular epinephrine (adrenaline; 0.5 ml of 1 in 1000 solution).

Penetrating wounds to hands and feet

A good deal has already been said about penetrating wounds. Punctures, especially to the sole of the foot, are common in MIUs. These wounds are often inflicted by glass, farm tools, rusty nails or fence spikes and should be assessed in terms of deep structure damage and foreign body (with a soft-tissue X-ray), and should be cleaned with a high-pressure flow of fluid (see above). For a puncture to the plantar foot, perform resisted tests of the flexors of the toes to assess movement of the tendons within their sheaths and inspect all joints in the vicinity of the wound for signs of inflammation. Such wounds are tetanus-prone and are also likely to be high risk by the DoH definition (see above) which requires you to administer human tetanus immunoglobulin *regardless of the patient's immunisation status*. There may also be grounds to prescribe a prophylactic antibiotic. The hazard of *Pseudomonas* infection, especially if the wound has been inflicted through the sole of a trainer, is leading to a move from the prescribing of flucloxacillin or co-amoxiclav to ciprofloxacin.

Children who receive such punctures to the heel are at a high risk of osteomyelitis. Refer them for paediatric review.

Pretibial lacerations

Pretibial lacerations are a very troublesome type of wound. The patient tends to be elderly, with very frail skin which is easily torn at the shin by the slightest knock. Sometimes a paper-thin piece of skin is peeled back in a triangular flap. On other occasions, the wound penetrates through the fat, and a thicker flap is seen. The tissue tends to curl up and retract, and it will often seem that there is a skin loss when there is not. A fresh wound is often very painful to clean.

The viability of the flap will depend largely on the circulation which it retains. A proximally based flap, one where the skin is unbroken at its proximal end, will enjoy a direct blood flow and has a better chance of survival. Other factors which are likely to influence the outcome include the colour and thickness of the flap, the width of its base compared to its length, the time elapsed before treatment, the effectiveness of wound toilet and the health of the patient. There are various classification tools for assessing the viability of skin flaps. The key decision which you have to make in an MIU is whether management should include an attempt to close the wound with paper strips or whether it should be allowed to heal by secondary intention.

These wounds heal very slowly. If the flap is not viable it may require skin grafting. There is also a risk of ulceration.

Open the wound and irrigate any dirt and clotted blood. Handle the flap gently and avoid folding it upon itself so that you reduce its circulation. Assess the skin for retraction: will it realign with the torn edges without tension? Is the skin dusky or pallid?

Moisten the flap with saline and tease it back into shape. Do not put it under any tension which could tear it and might reduce its blood supply. If the flap will realign, apply the minimum number of Steri-Strips to close the wound without excessive tension on the torn skin. Cover it with a non-adherent dressing and use a supportive bandage to secure it. Do not put adhesive tape on frail skin. Various types of dressing and support are advocated in different hospitals. Advise plenty of rest and elevation and refer the patient to the practice nurse. You may also have tissue viability services to advise on the care of skin tears. If so, involve them at the outset. Emergency nurse practitioners (ENPs) rarely see the outcome of these injuries and expert help will optimise initial management.

Assess the patient's tetanus status. Elderly females have often not been immunised.

If the wound edges cannot be brought together without undue tension apply a supportive non-adherent dressing. There is some debate about the use of Steri-Strips for flap wounds but there is no evidence that they cause problems if they are applied without excessive tension (Box 16.5).

Elderly patients with frail skin are at risk of repeated injuries of this kind and advice on prevention will be a part of on-going care of the injury.

High-pressure injection wounds

Delayed tissue destruction, caused by high-pressure injection, happens when an industrial device which expels paint or grease through a fine nozzle at high pressure, penetrates skin and discharges into tissue, usually on the hand. The injury may look innocuous at first, but it has the potential to develop into a devastating cocktail of infection, foreign body, chemical injury, necrosis and swelling. The patient may lose the limb if the injury is underestimated. An urgent surgical exploration is needed.

MINOR BURNS

The general division of minor injury presentations between limb and midline, with significant common features within and differences between these categories, does not apply consistently to burns. Minor burns

are generally small and localised to a patch of skin but it does not matter much whether they are on the limb or the trunk: they do not penetrate to deeper parts and they do not threaten organs. There are delicate areas where superficial burns are more troublesome, and most of these are in the midline, but they do not carry the notional threat to life which drives the management of other midline injuries. Burns can involve systemic threats, if smoke, chemicals, explosives or electricity are involved, if the patient has sunstroke or if the burn becomes infected, but these are unusual in an MIU. A minor burn tends to be a superficial phenomenon whose most difficult initial feature is pain.

Assessment

The relationship between the severity of a fresh minor burn and the patient's triage priority is complicated by two factors:

- Severe pain is a feature especially of less serious, fresh burns because the nerve endings in the skin, which can be destroyed by a deeper burn, are intact. Pain is a triage priority. The single measure which brings relief most quickly is cooling of the burn with wet compresses. Oral paracetamol is valuable, especially for children. Give immediate first aid to patients who present with fresh burns.
- First aid to a fresh burn in the first few minutes, cooling of the injured surface, may reduce the damage which continues in the heated tissues after the injury.

The likelihood that a patient with a life-threatening burn will present in an MIU is not high but there are some situations where you may have to take quick action or exclude serious injury. Always establish the nature of the burning agent at triage.

Chemical burns

In the case of a fresh chemical burn, quick action is needed to return the skin to a neutral pH. A low pH, between 1 and 7, is in the acid range, with 7 neutral: a pH between 7 and 14 is alkaline. Use litmus paper to obtain a reading for your patient.

Take a history. Get the name of the product. Ask if the patient has brought any container. Ask for any manufacturer's literature on the product and on any antidote. Find out what action the patient has taken, and what effect that has had. Get a colleague to look up Toxbase while you stay with the patient, to establish the correct initial management of the situation. Assess the risk (especially with a child) that the patient has swallowed the substance. Usually you will remove any contaminated clothing and irrigate a recent chemical burn with a copious amounts of water as soon as possible. Ensure that the patient is positioned so that the substance is not spread further around the body and protect yourself from contamination. Recheck the pH and continue with irrigation at least until the reading is neutral. If the chemical is a dry powder, do not wet it. Brush it off dry. The destructive action of an alkaline agent is more prolonged than that of an acid. Unless there is clear, expert advice, do not put any neutralising chemical in contact with the substance on the skin. This may trigger further damage or an allergic response, and it may make things worse if the patient is mistaken about the causative agent or if there are other substances mixed with it. The process may also increase the heat generated in the injured area and worsen the burn.

Smoke

A history of exposure to flame in a confined space raises the question of smoke inhalation. The patient may have breathed poisonous or irritant substances. Even when the damage is life-threatening there may be no serious signs at once. The patient may progress to collapse caused by swelling in the airway and lungs, hypoxia or poisoning, and the crisis may be irreversible. There is also the danger of a severe pneumonitis caused by irritants in the lungs. A patient who has inhaled dangerous hot gases may have burns and blackening around the nose or mouth, singeing of facial hair, a smell of soot on the breath, may be hoarse and sputum may be discoloured. If there is any sign of hypoxia, which may be assessed by physical signs such as cyanosis or a neurological deterioration, or if there is evidence of respiratory difficulty, which may include wheeze, cough or stridor, the patient should be treated as an emergency and resuscitated. ABC is the priority. The airway is in danger and the patient needs oxygen. The most senior anaesthetist available should be called. If the history is the only indication of risk and the patient seems well, there must still be an immediate medical assessment. A full clinical examination, with chest X-ray and arterial blood gases investigation, will be performed.

Electric shock

A patient who has received a high-voltage electric shock is not likely to appear in an MIU. Patients will present who have suffered shocks from household supplies.

Electricity enters the body through the point of contact, creating a burn, and travels through the least-resistant pathways, which tend to be skin, nerve, muscle and the circulation to an exit point. It then leaves the body, causing a further surface burn. The patient's contact with the power source can be prolonged, and the injury worse, if the voltage is high enough to cause muscle contraction, which will prevent the patient from letting go. There may be injuries at

any of the structures involved, and the rhythm of the heart may be disrupted.

Look for burns on the body surface, assess circulation, innervation and movement, check vital signs and perform an electrocardiograph.

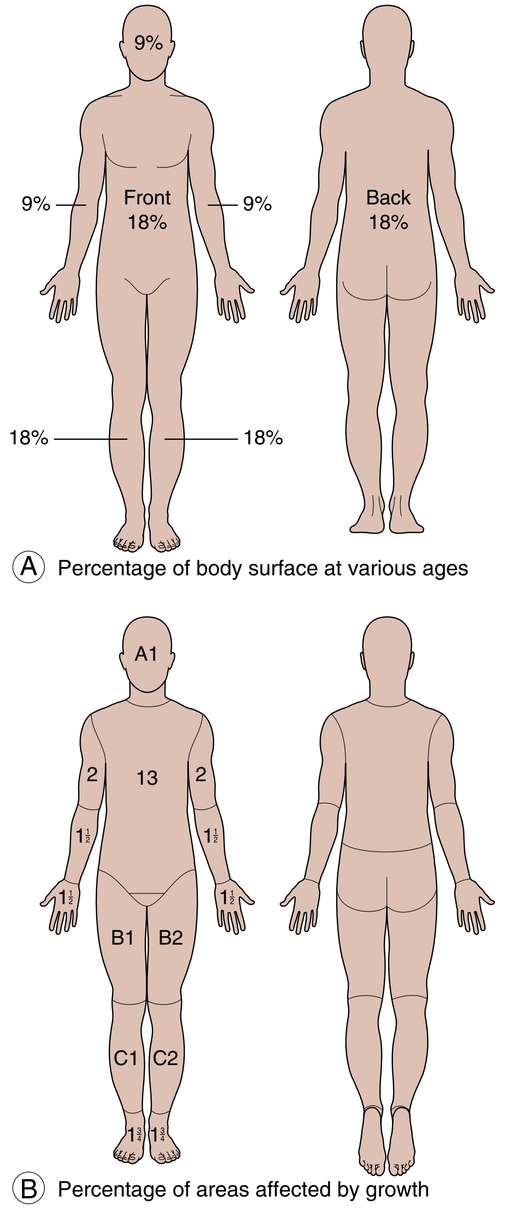
Non-accidental injury in children

Glasgow and Graham (1997) cite the probable incidence of 10–15% of burns to children as non-accidental. They estimate that 10% of all physical abuse of children takes the form of burns, and that burns are involved in a smaller number of sexual abuse cases. You should be aware with children who have been burned of other injuries which are consistent with abuse: the small circular mark of cigarette burns, the glove or stocking demarcation line of the burn on a child who has been immersed in hot water, or the mark of a hot contact on a body part, such as the buttocks, which a child would not be likely to injure by accident. More general signs of abuse may include a delay in seeking treatment, an injury which is not compatible with the mechanism described and a history of other attendances. You will have child protection procedures in your area and you will initiate these if there is a suspicion of a non-accidental burn.

Types of minor burn

The commonest types of minor burn are scalds (wet heat), flames and hot appliances (dry heat) and radiation from the sun:

- Scalds (wet heat): splashes, spillages and, occasionally, immersion in hot liquids, are the commonest cause of minor burns. Hot water, steam and cooking oil are the main agents. The kitchen and bathroom are the chief sites of injury.
- Flames and hot appliances (dry heat): dry heat burns is a mixed category of common, non-liquid burns, house fires, objects which produce a flame (gas cookers, cigarettes), appliances which are heated by electric elements (irons, electric cookers, soldering irons) and objects which contain hot water (radiators, hot water bottles, kettles). An object, like a hot water bottle, which is designed to provide heat and which will not cause a burn on a brief contact may inflict a deep burn if the user has a reduced awareness of pain and stays in prolonged contact. This can happen if the user has reduced sensation in the burned area or becomes unconscious because of illness, alcohol or drugs.
- Radiation from the sun: patients appear every summer with sunburn, or its artificial counterpart the sunbed burn. These burns are painful and sometimes quite large but are rarely serious.



	0	1	5	10	15	Adult age
A = ½ head	9½	8½	6½	5½	4½	3½
B = ½ one thigh	2¾	3¼	4	4¼	4½	4¾
C = ½ one leg	2½	2½	2¾	3½	3¼	3½

To estimate the total of the body surface area burned, the percentages assigned to the burned section are added. The total is then an estimate of the burn size.

Fig 16.6 Assessing the size and severity of burn injuries. A, Adult assessment using Wallace's rule of nine. B, Child assessment using the Lund and Brouder burn chart.
Source: From Alexander, et al., 2000. Nursing Practice: The Adult Hospital and Home, second ed. Churchill Livingstone.

Definition of a minor burn

The management of burns is based on reasonably exact calculations of three factors: the size and the depth of the surface injury and the part of the body which is injured. There are other indicators of seriousness, such as the risk of inhalation, but burns with such complications are not minor.

Size of the burn

The size of a burn is calculated in percentage of total body area (Fig. 16.6). Erythema, the redness without blister or wound, which is the most superficial burn, is not calculated as part of the percentage.

The 'rule of nines' is a rough guide to estimation of the size of a burn. This divides the percentage area of the body into multiples of nine and it is easy enough to learn to carry in the head:

- head 9%
- each arm 9%
- front of trunk 18%
- back of trunk 18%
- each leg 18%
- perineum 1%.

The proportions of a child differ from those of an adult and change dramatically from infancy to adolescence. The Lund and Brouder chart in Fig. 16.6 offers a scale of percentages at different stages.

Another useful method of assessing a small burn's percentage size is to calculate that the patient's hand, with the fingers together, will cover about 1% of the body surface. The percentage of burn has to be factored with the other two elements, depth and site, when deciding whether or not a burn is minor, but as a rough guide for an adult patient, burns of less than 5% will not require specialist advice or admission. If the burn exceeds 10%, medical guidance is needed.

Depth of the burn

It may not be possible to tell how deep a burn is on first examination, and the patient's pain will be the first priority. However, a history will give the first indication of the depth of the burn. The two factors to be considered are the amount of heat generated by the burning agent and the duration of the contact. The amount of heat may be a question of the boiling point of a particular liquid, such as water or cooking oil, or it may have to do with the voltage of electricity or the strength of a chemical solution.

Burn depth is described as follows:

- **Epidermal**: red, unbroken skin or erythema. It can be very painful, but the burn is superficial and will heal without complication. Milder areas will sometimes disappear on the day after the injury. Epidermal areas are not included when measuring the percentage of skin which has been burned. The patient will have blanching of the skin on pressure followed by a brisk capillary refill.
- **Superficial, partial thickness**: there are, or will be, blisters full of serous fluid. When these burst, the underlying skin is pink, tender and exudes for some days. The skin will heal from its own base layer without scarring or contracture of the skin. Capillary refill will be slower than for epidermal burns.
- **Deep, partial thickness**: the burn is usually of irregular depth and reaches the base of the dermis. It looks paler than a superficial burn, and sensation may be reduced or absent on its surface. Some hair follicles may be visible in the base tissue. The skin will not blanch to pressure.
- **Full thickness**: this type of burn penetrates through the skin to the level of the superficial fascia. It looks white, the base feels leathery and inelastic. There will be no sensation in the base tissue and no blanching to pressure.

Deep, partial-thickness burns and full-thickness burns have lost the capacity to regenerate from the base of the wound. These burns heal very slowly and imperfectly, inwards from the edges, with scarring and contracture.

The patient will carry a permanent reminder of any such burn and may suffer other disadvantages if the injury is large, cosmetically significant or placed over a joint. Refer the patient to your local burn service.

Site of the burn

- Face: minor burns to the face, such as epidermal scalds, cannot be dressed and can be very painful at the outset. However, the face heals well and there should be no lasting problem. More serious facial burns, and especially those which are deep, threaten the airway or involve the eyes, require referral.
- Hands: a small scar on the extensor surface of a joint of the hand can cause contracture and a loss of movement. The sense of touch is most sensitive in the hand, and any damage to the skin may reduce it. Have a low threshold for the referral of hand injuries. If the hand is restricted by dressings or painful injury, it is prone to stiffness.
- Perineum: burns anywhere in the region of the genitals and anus are embarrassing, painful, hard to dress, incompatible with normal movement and prone to infection. There may also be a question of non-accidental injury.
- Joints: assess any burn which crosses a joint to ensure that the patient will suffer no long-term loss of movement. A burn which is circumferential at any part of the body may act as a tourniquet through swelling around the burn and inelastic, burned tissue; this could cause distal necrosis.

- Soles of the feet: patients will occasionally contrive to stand with both bare feet on a hot substance (for example, walking on a beach where someone has just emptied the used coals from a barbecue). If the patient cannot bear weight on either foot then it is unlikely that even crutches will help, and he or she may need hospital admission for nursing care and dressings, until the most painful phase is over.

Treatment of minor burns

The definition of a burn as minor is meaningless if it ignores other aspects of the situation, such as the inability of an elderly patient to cope at home or a possible non-accidental injury. Assess every situation on its merits.

A minor burn is painful. It may become an open, moist wound, and this may lead to infection.

If a patient telephones for prehospital advice for a burn, advise a period of cooling of the burn with wet cloths of at least 30 minutes, simple analgesia, and a cling film wrapping to come to hospital.

If the patient presents with a fresh injury, tackle pain as a first priority: cool the burn with wet compresses for at least 30 minutes and give paracetamol. Do not rush the cooling process: it will reduce the damage to the tissues caused by retained heat and it is the most effective analgesic for the injury. Take a full history and record the patient's tetanus status, allergies and medical history.

Carry out an initial assessment of the injury: document its site, size and the appearance of the injured skin. Make a diagram. Note the presence of erythema, blisters, any broken skin and the apparent depth of the burn. Test awareness of light touch and blanching over the injured area.

Clean and dress the burn. Burns are prone to infection, and dressing technique should be aseptic.

Policies vary from place to place, and person to person, on the treatment of blisters and the dressing of burns. You will dovetail your own policies and procedures to practice in your local burns unit.

A moist, petroleum jelly dressing is comforting on a burn but the gauze adheres as it dries out over a day or two. It is probably not an advantage to have to review and redress a burn repeatedly simply because the dressing has no durability. Mepitel is a synthetic non-adherent dressing which can be left alone until you wish to review the progress of the injury.

Burns continue to develop over the first 24 hours and, in cases where the injury does not require an immediate referral to a burns unit, you should arrange an early review, either in your own area or by a practice nurse, when the pain has settled, to confirm your final plan of management. If a wound is exuding fluid the patient should return for a new dressing if the dressing soaks through: a wet dressing is a medium for infection.

The issues on the first day are a provisional assessment and documentation of the injury and, above all, management of the period of severe pain, which usually lasts for 4 to 8 hours.

The issue of blisters has several themes: the thicker the walls of a blister, the deeper the burn; the larger a blister, the more inconvenient it is; blisters on joints will cause problems for movement; it is difficult to see the depth of a burn if a blister covers it; opening a blister can introduce infection; the unscheduled bursting of a large blister can be inconvenient and messy. The options for treatment are leave it alone, remove it completely or aspirate it. There is no conclusive evidence on blister management and practice has tended to vary from place to place and over time in one place.

The National Institute for Health and Care Excellence (NICE) has issued guidelines for the care of minor burns and scalds (2015). They advocate, for superficial dermal burns, leaving blisters alone to reduce the risk of infection, and aspiration rather than deroofing when they are awkwardly sited and likely to burst. However, deeper burns will be difficult to assess if covered by a blister and deroofing may be required.

In general one may assess the likely depth of the burn associated with an intact blister from the severity of the mechanism (temperature and duration of contact with the burning agent) and the size and thickness of the blister wall. A thin-walled blister is translucent and coloured by the pale yellow serous fluid within.

Burns to the face and to the perineum may not be suitable for dressing. If the skin is not broken, and the main problem is discomfort from clothes and walking, some perineal burns can be dressed by layering non-adherent silicone around the skin creases, moulding and snipping a large wound pad to fit, and holding the dressing loosely in place with an athletic support. This will give comfort but will not help if there is a risk of infection.

Tell the patient to return if any infection signs, local or systemic, appear.

Children may develop toxic shock syndrome after a burn, and must return if they become unwell in the days after injury (Box 16.16).

Box 16.16 Toxic shock syndrome and the child with a burn

- A *Staphylococcus aureus* toxin can enter any wound, but is particularly prone to entering children's burns.
- Symptoms are fever, rash, pyrexia, malaise, vomiting and watery diarrhoea.
- Requires aggressive inpatient management and can be fatal.
- All parents should know of the risk if the child has a burn, and should be told to bring the child back immediately if he or she becomes unwell during the time of healing.

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